EVERYDAY INDIAN PROCESSED FOODS

K. T. ACHAYA

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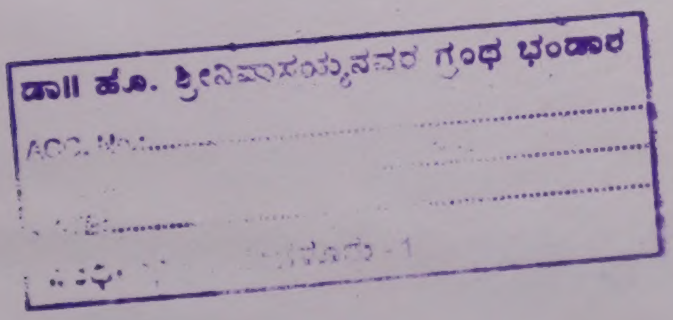
India—The Land and the People

Everyday Indian Processed Foods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PREFACE

This is a book on processed foods that outlines in readable terms their chemistry, technology and nutrition. Foods described as processed run a wide gamut. Even basic staples like rice, wheat and dhal reach the market after going through mechanical processing operations. The milk distributed in many cities and towns today is a product of sophisticated technology. Delicately-controlled processing operations lie behind every packet of tea or coffee. Products like bread, biscuits, jams, squashes, pickles, vanaspati, chocolates and soft drinks purchased from the market exemplify for most of us what processed foods are, but few are aware of the fascinating chemical, biological and engineering principles that go into their preparation, sterilisation and packaging. Even products long made in the home, like achar, murabba, papad, idli and gulabjamun, have been subjected in recent years to critical scientific study which has led to technological products now commercially available for the convenience of a busy housewife.

This science of Indian food processing, with a dash of history or geography, is what this book is all about. An occasional departure, as to exotic cheeses or wines, is justified by the inherent fascination of their science or technology.

Mysore K.T. ACHAYA

CHAPTER 1

The Foundations

Cereals and Pulses

RICE

Is THERE ANY Indian whose spirits are not lifted by the appetising smell, the snow-white appearance, the delicate nutty taste and the soft chewy texture of a plate of boiled rice! Even the names of traditional varieties are evocative. Basmati is from *bas* (smell or savour) and *mati* (sense or mind), Dilpasand is heart's delight, Hansraj, the king of snow-white swans, Dudhkalma, the milk-white rice of Bengal, and Sannarsana, the small-grain rice of Karnataka. Even the new varieties are occasionally poetically named: Jaya, Padma, Sona, Madhu, though we also have the prosaic but perhaps technically convenient names like Co-25, MTU-15 and T-136.

There are strong regional preferences for size, shape, flavour and cooking texture. In broad terms, rice is classified as fine, medium and coarse. Fragrant, long-grained varieties are prized in the north even for everyday eating. In the south these are used only for making biriyani, pilau or ghee rice, and a coarser quality is preferred for everyday use. Parboiled rice, slightly yellow in colour, is popular in eastern India, whereas parboiled rice of a rather strong boiled flavour is popular in the far south. Everywhere in India, rice that is at least a year old is preferred since it cooks to a firm consistency and has separate grains; this is in contrast to countries of the Far East, where a semi-glutinous mass after cooking is desired.

Milling and polishing

Paddy has a coarse outer brown husk which makes up about a quarter of its weight. Below this lies a fine, silky, light brown pericarp layer which when removed is called rice bran, a traditional cattle-

feed known as thavudu or goora. At the end of each grain is lodged the germ, a hard, tiny, white granule carrying the embryo from which springs the seedling should the rice grain be planted. A similar germ can be easily observed if a groundnut is split into halves.

Paddy milling is designed to first split and then remove the coarse husk, and in so doing, some or all the bran and also the germ comes off. Such extensive polishing gives a snow-white rice which is in consumer demand. However, many nutrients like vitamins and proteins are present in the bran and germ, and these will be lost to the eater of polished rice. This will be discussed later.

The milling of rice is a hoary traditional operation carried out in many ways. In the simplest of these, paddy is placed in a cylindrical wooden or stone mortar or chakki, and pounded with a stout wooden pestle using the hands or one foot. Dehulling is accomplished, but much of the rice gets powdered too. Winnowing is employed to separate whole rice from the rest. Upscaling of the pounding principle is found in the dhenki, in which a wooden pole, pivoted in the middle and carrying a short wooden pestle at one end, works seesaw fashion to pound paddy held in a wooden mortar fixed in the ground. In the horizontal single-stone huller, two circular stone cylinders revolve inside a casing on which is fixed a steel blade which cracks the husks; one stone piece is grooved to receive the full paddy grain and the other to discharge the white rice grain. In a double huller, the latter may be passed, after some abrasive husk has been added, through another similar polishing arrangement with a finer setting to remove remaining adhering bran. The coarse husk pieces are easily separated from the broken grains and bran, which may themselves be further resolved by winnowing. Another type of unit is the sheller, which consists of two iron discs coated with a rough mixture of emery and cement. The upper disc is fixed while the lower revolves, and paddy entering from a feeder at the top is sheared of its husk as it passes through the adjusted space between the two discs. The emerging mixture is separated by winnowing into husk, whole paddy, whole grains, large broken grains, small broken grains and bran. Moving down a vibrating machined board which has rough projections on it, whole rice rolls down more easily than do paddy grains, and can be separately collected; the paddy is then added to the next processing batch. Another arrangement, used only for polishing, is

an inverted stone cone spinning in a wire screen into which project rubber fingers. These hold the grain while any residual brown bran is polished or pearled away; oil or talc may be introduced during the operation to add lustre to the grain.

High grain breakage occurs during traditional processing. These broken grains, called thari, are not however wasted but put to use in speciality dishes, or where ground rice flour is called for, such as in making idli and dosai. Difficulties in recovering each product separately have led to improved paddy processing methods. In a rubber belt sheller, the paddy is not dropped from the top, but carried on a rubber belt to the space between the discs. Even more advanced shellers have a pair of rubber or rubber-coated rollers rotating in opposite directions at different speeds while the paddy grain passes down between them; breakage is negligible, yields are high and if the shelling is done in two stages, husk and bran can be separately obtained. An even more recent development is the modern rice mill, in which two essential principles are utilised to obtain each constituent of a grain of paddy in clean form. The first principle is that of shearing within a gap between two surfaces: the size of the gap, the roughness of each surface and the speed of movement can be varied to suit the purpose desired, whether this be husk-cracking, husk-shearing, coarse polishing or fine polishing. The second principle is the separation of constituents by differences in their weight, size, shape and flow characteristics using such operations as gravity fall, sieving, air currents and vibrations. Usually these operations proceed in a continuous sequence. Modern rice mills of small capacities suited to the scattered operations in India are now manufactured in the country, and consist of the following units inorder : (a) precleaner, a series of baffles first and then a sieve; (b) rubber roll sheller for removing the hulls; (c) hull and brown rice separator; (d) bran huller; (e) separator for bran and rice with baffles and air aspiration; and (f) a sieve to separate fine from coarse bran. Each part of the rice grain is thus collected separately.

Parboiling

One more technique for getting rice from paddy is parboiling, which involves steeping of the paddy in cold water for a few days and subsequent boiling of the water till the grain is soft, after which the grains are spread out to dry. This treatment makes the husk more

easily detachable, renders the grain less brittle and more elastic, and toughens the outside of the rice grain by a process of starch gelatinisation. These operations result in a much-improved yield of whole rice during subsequent milling of the paddy. About half the rice grown in India is parboiled, and today parboiling has been both commercialised and improved. One commercial method is essentially an upscaling of the home technique of steeping the paddy in cement troughs for 1 to 3 days followed by steaming for about 10 minutes in metal vessels with false perforated bottoms, on which the rice is placed as the water boils below it. Another large-scale method is initial steaming for just a minute or two, cold steeping for 1 or 2 days, draining, and a second steaming for a few minutes, followed by drying of the parboiled rice spread on the floor. Steeped rice may also be finished by roasting in a bed of hot sand. All these are slow operations taking several days, and parboiled rice may acquire a bad smell as a result of fermentation by micro-organisms. Also, poisonous mycotoxins may be elaborated if moulds of certain kinds, which grow on wet foods, develop. New commercial parboiling techniques shorten the process to one of soaking for a few hours in hot water followed by drying, when both the development of smell and of toxins is obviated, while the desired surface gelatinisation does take place.

Rice processing industries

Over 52 million tonnes of paddy are grown in India every year, to be thereafter processed by many units, small and big. Spread out all over the country are some 73,000 single hullers, 2,500 double hullers, 8,000 hullers-cum-shellers, 3,800 shellers and 5,000 modernised rice mills, the last category being a comparatively recent development over the last decade. There is deliberate effort by government to encourage through financial incentives the replacement of hullers with sheller-hullers which give a higher outturn of rice. Commercial parboiling using modern equipment has led to products that are totally free of smell, and, as we shall see, of excellent nutritive value. The golden colour that rice assumes if the parboiling process is slightly prolonged is greatly in demand especially in eastern India, even though it disappears on cooking. This preference may be connected with the pale cream colour that rice assumes on ageing, which has been traced to at least three causes. One is a reaction between proteins and sugars that is of common occurrence in many foods, and

is called the Maillard (pronounced My-yard, the name of a French scientist) reaction; it can be either an undesirable one, as in milk products in which the nutritive value is reduced, or one that gives rise to the appetising smell of roasted coffee, fresh bread and hot chapatis. We shall look a little deeper into the Maillard or browning reaction when discussing chapatis later in this Chapter. The second cause of rice yellowing may be an enzymic oxidation reaction of constituents called polyphenols. These are found in many food products and give rise to a darkening of colour; a well-known, very fast example is the browning of cut pieces of apples or pears. The third cause of yellowing is the engendering, by moulds that grow on the surface of rice, of yellow products called mycotoxins, some of which are quite toxic to human beings and animals.

Puffed rice and beaten rice

Both paddy and rice are puffed. The product from paddy is called kheel and its ground product sattu. However, this is a small operation compared to those used to produce puffed rice, muri or murmura. Parboiled rice is preferred for puffing, and the rice in handfuls is thrown into very hot sand held in a kadai over the fire. The sand is turned around with a metal ladle, and as soon as the rice begins to swell and crack, the contents are poured off into a sieve; the puffed rice is collected, and the hot sand retrieved for reuse. Rice steeped in or roasted with salt water is used for parching in eastern India. Commercial units consisting of roasting cylinders through which the rice travels in hot sand, which is sieved through and passes back into the cylinder, are now commonly in operation. White, glistening, plump grains are what the user expects of puffed rice.

Beaten rice (chura or aval) is expected to be thin, papery, friable and as broad in shape and as white in colour as possible. Paddy is soaked in water for 2 or 3 days till soft, and the same water is brought to the boil for a few minutes and cooled. The swollen grains are next placed in a concave iron or earthenware pan over a strong fire till the grains burst, after which they are pounded with a pestle to flatten the grain and remove the husk, which is thereafter winnowed away.

Nutrients in rice and its products

The top half of Table 1.1 shows the various macronutrients present in brown rice (which still carries its coat of bran), and in polished,

hand-pounded and parboiled rice. Polished rice has lost its bran and also its tiny germ, and since these are rich in protein, fat, ash (which is a measure of inorganic mineral constituents), and fibre (rough indigestible material), naturally these constituents are all lowered; hand-pounded rice, which retains a good part of the bran, is close in composition to brown rice. Since starch, protein and water in much the same relative proportions make up 95 to 99 per cent of all these forms of rice, their calorific value is almost identical at a figure of 350.

TABLE 1.1

A. Major Constituents of various forms of Rice

	Brown rice	*Polished white rice*	*Hand-pounded rice*	*Parboiled rice*
		All figures as percentages		
Starch	77.1	80.9	78.1	78.0
Protein	7.5	7.1	7.7	7.0
Fat	2.4	0.4	1.5	0.8
Ash	1.2	0.5	0.8	0.5
Fibre	0.9	0.1	0.9	0.1
Moisture	10.9	11.0	11.0	13.6

B. Retention of Vitamins and Minerals in various forms of Rice

	Brown rice		*Polished rice*	*Hand-pounded rice*	*Parboiled rice*
	Quantity	*%*			
	micrograms		*As percentages of the quantity in brown rice*		
Thiamine	320	100	15	66	72
Riboflavin	56	100	35	87	66
Niacin	4600	100	37	85	83
Folic acid	36	100	22	60	30
	milligrams				
Calcium	40	100	25	65	95
Iron	2	100	155	145	133

Note : 1 gram = 1000 milligrams (mg)
1 mg = 1000 micrograms (mcg)

The difference lies in the vitamins and minerals, since these are present largely in bran and germ which get removed on milling. The lower half of Table 1.1 shows the percentages of these micronutrients that are retained after processing rice in different ways. Polished white rice is the worst: only about a third of the vitamins and half the calcium are left after the polishing operation. The figures for iron can be misleading, since any iron machinery used in processing rice will shed metallic iron into the product, but this is unfortunately not in a form that the body will absorb and use when the cooked rice is eaten. Hand-pounded rice retains about three-quarters of the vitamins and calcium and it is on these grounds that its use is advocated. Thiamine or vitamin B_1 is of particular importance. Insufficiency in our food gives rise to a disease called beri-beri which takes two forms. In dry beri-beri, there is a loss of appetite, a tingling and numbness in the legs and hands, and a drooping of the feet, while the wet form is characterised by dropsy (fluid accumulation), palpitation, breathlessness and a weakness of heart muscle that could lead to heart failure. In areas of India where hand-pounded or parboiled-and-milled rice is used, beri-beri does not occur, but it does when polished rice is the main food. But hand-pounded rice, though it has a nutty taste when fresh, does not cook really white and also goes rancid rather easily on storage, and is therefore losing out in popular appeal. Rice processed after parboiling, whether by machine milling or hand pounding, has many plus points. What happens during the parboiling operation is that the nutrients on the surface are driven into the body of the grain; also, a layer of gelatinised starch forms on the surface of parboiled rice, and this prevents the nutrients from leaching out during boiling. In fact, nutrient differences between the various forms of rice would widen if cooked samples were to be analysed. Modern methods of commercial parboiling yield products of excellent taste and appearance which do not stick together after cooking. Stored parboiled rice also resists insect and mould attack better than the other forms. It seems to have many good things going for it.

Both puffed and beaten rice have undergone fairly drastic treatments, so it is not surprising that their levels of nutrients, especially vitamins and minerals, suffer in consequence. About half the thiamine disappears from both products, and riboflavin is all but destroyed, especially in the puffed product. Niacin is fairly well retained, as is calcium.

The common practice of washing rice in India before use in order to remove stones, sticks, adhering powder and the castor oil that is sometimes smeared on for better storage, removes with it a high proportion of B-vitamins. Cleaning rice by inspection and a dry rub with cloth is a good alternative. The practice especially in south India of using extra water for boiling and then discarding the excess after cooking leaches away valuable nutrients. This can be easily avoided by using just as much water as the rice will absorb. This practice is again much easier with parboiled rice, though washing it leads to hardly any leaching loss.

There have been efforts the world over to fortify rice with extra nutrients, but these have not been very successful. One method is to fortify a small amount of rice fairly heavily with the required nutrients, and to mix say 10g of this with 2 kg of ordinary rice before cooking. In the other, all the rice is impregnated with the desired quantity of nutrients, which are then sealed-in either by using a harmless coating, or by some form of surface gelatinisation such as parboiling. The size of India's rice crop, and its decentralised and mostly small scale of processing, do not augur well for the success of such fortification procedures.

Other rice processing possibilities

Certain processed foods based on rice may find a market in India, even if on a limited scale considering the lack of buying power. Instant rice, as it is euphemistically called, is a common product in supermarkets abroad, cooking in 2 to 10 minutes in a fixed quantity of added water which gets totally absorbed. This is rice that has been almost fully gelatinised by cooking with water, steam or hot air; thereafter it is fissured (to enable rapid penetration of hot water for final kitchen cooking) either by slow drying, or by expanding or puffing through a sudden increase in pressure or in a current of hot air.' Growing use of pressure-cookers that cook even ordinary rice (and other foodstuffs) quite rapidly is however a factor that could limit the success of quick-cooking rices in India.

Rice noodles are widely popular in many countries of the Far East and South-East Asia that have been subject to Chinese influence. Rice flour is cooked with some water to a dough which is forced through dies, cut to the required length and dried. Vermicelli, longer and thinner, can also be made from rice. Being precooked, these are

convenience foods. In Europe, especially Italy, and on the American continent, wheat-based noodles and vermicelli are the mode. Egg noodles must contain about 5 per cent of egg solids, which yellows the product, and adds nutrients.

Following the enormous success of such ready-to-eat breakfast cereals as corn flakes, rolled oats and shredded wheat, which require just a little warm milk and sugar, use of rice also has been explored. One flaked product consists of individual parboiled rice grains that are first cooked with sugar syrup, dried, and surface-gelatinised; this is followed by flattening between flaking rolls, and quick, slight puffing in an oven. Industrial puffed products are of two kinds. In one, wet grains are individually expanded by effecting a sudden drop in pressure through ejection from a puffing gun. In a modern cooker-extruder, both these operations are combined: the rice mass is cooked and cut to various shapes and sizes as it emerges from the machine to expand suddenly when the pressure drops. To give a good taste, other ingredients are mixed with the rice, or coated after extrusion. Savoury snacks can also be made similarly using such cooker-extruders.

WHEAT

Till the forties, use of wheat was very restricted in south and east India. Enforced rationing during the Second World War and occasionally thereafter gently pressurised people there into accepting wheat. The striking increase in wheat production starting in the mid-sixties consolidated such adoption. Wheat production is rising twice as fast as that of rice, and the 1980 wheat output of 38 million tonnes is catching up with the rice harvest of 52 million tonnes. About a third of all families in south India now eat wheat every day, and even the average daily consumption is 40 to 50g per person. Calcutta city shows a strong pattern of one rice meal and another wheat meal a day. The southern and eastern states have even taken to growing wheat.

In contrast to the threshing of panicles of rice in the farmer's field to yield paddy which still carries a stout cover, the beating of heads of wheat loosens the brown grains so that they emerge carrying just a coat of bran. Of course, like all seeds, wheat also has a germ at one end; this carries the embryo, from which will spring the seedling if the grain is sown. The percentage proportions of the inner grain (or endosperm to give it its technical name), the bran

layer and the germ are 83, 14.5 and 2.5. Surprisingly, these are almost identical with those in rice, even though the two grains look so different. Table 1.2 shows the nature of the three wheat components. The inner endosperm is mainly starch, and its protein content is low. The bran has high proportions of protein, fibre and ash, while the germ is particularly rich in protein and fat. The difference in vitamin and mineral contents is even more striking. Bran carries particularly high levels of niacin, pantothenic acid, calcium and phosphorus, and wheat germ is rich in tocopherol (vitamin E), thiamine, pyridoxine and potassium.

TABLE 1.2

Composition of Wheat and its Components

	Whole wheat	*Endosperm 83%*	*Bran 14.5%*	*Germ 2.5%*
		Figures in g/100g		
Moisture	12	12	12	10
Carbohydrates	69	76	44	46
Protein	12	10	15	28
Fat	2	1	5	9
Ash	2	0.5	10	5
Crude fibre	3	0.5	14	2
		Figures in micrograms/100g		
Thiamine	350	200	810	2,000
Riboflavin	160	70	620	700
Niacin	5,400	1,100	27,500	4,500
Pyridoxine	500	200	1,800	3,000
Pantothenic acid	1,300	750	4,500	1,000
Folic acid	36	15	65	500
Biotin	10	4	45	17
Carotene	5	—	—	200
Tocopherol	500	—	—	27,000
		Figures in milligrams/100g		
Calcium	45	18	200	70
Iron	4	1	20	8
Phosphorus	430	126	2,100	1,100
Magnesium	180	28	680	270
Potassium	450	105	210	840

Note : One gram is 1000 milligrams (mg)
One milligram is 1000 micrograms (mcg)

Chakki grinding

There are two ways in which wheat is processed in our country. One is the traditional method utilised by many households, which grind their cleaned wheat between heavy granite stones of equal diameter, the bottom one standing stationary while the top is being revolved by hand using an upright wooden handle fixed on its periphery. The ground whole wheat atta spilling out from the gap between the stones is collected and sieved to remove the coarsest particles. These are used as animal feed or discarded, and the rest is used for making chapatis and other food items. A small, electrically-driven chakki is an enlarged version of the same principle, sometimes with metal discs taking the place of the stones. There are as many as a lakh of chakkis of all kinds in India.

Nutritionally whole wheat flour is an excellent way of getting all the nutrients present in the endoplasm, the bran and the germ, especially if the sieving of coarse particles is omitted, which it sometimes is. The nutrients in wheat are unevenly distributed within the grain, and using whole wheat atta ensures full value in the chapati.

Making a chapati

Other factors involved in making a chapati have been scientifically examined. The basis of the use of wheat flour to make a dough which has a cohesive structure is the presence in wheat of a unique protein called gluten. Other cereals, lacking gluten, cannot make a true elastic dough. If wheat flour is held under a slow stream of running water, all soluble materials wash away leaving a rubbery ball of gluten. In fact gluten is made in just this fashion for preparation of the sticky sweetmeat sohan halwa. Wheats carry about 10 to 13 per cent protein and of this 8 to 10 per cent is gluten. When wheat flour is kneaded, it can take up more than half its own weight of water without leaking, and it is gluten that gives the dough its sticky, rubbery and extensible quality. Various wheats yield doughs of different characteristics, which in turn determine their suitability for making chapatis, bread, biscuits, cakes and vermicelli.

The flours ground from traditional Indian chapati wheats have a very high capacity to absorb about two-thirds their own weight of water. The ensuing dough is non-sticky and shows a moderate resistance to being stretched, but once extended it will stay that way; in

other words it is highly extensible. Gluten is itself a mixture of three constituents. One is the gliadins, which are very extensible but have poor flexibility; with water they yield long but thin ribbons, and they confer extensibility on the dough. Glutenins have opposite characteristics; their mixtures with water form thick sheets that are quite flexible but will break when pulled apart. Though glutenins from various wheats themselves vary quite a bit in their properties, they all contribute strength to a wheat flour dough. The third gluten component, residue proteins as they are called, are brittle and tend to form crumbs, rather like old rubber does. It has been shown that wheats that carry about equal proportions of these three constituents, and an overall high gluten content, give chapatis that are soft and that puff well; an excess of residue protein shows up in a leathery chapati and overmuch gliadin in a somewhat stiff one. The relative proportions likewise govern the suitability of various wheats for making loaf bread.

Chapati colour is also a surprisingly complex matter. At the start of the green revolution centring on wheat in the late sixties, high-yielding Mexican wheats with dwarf plants, such as Sonora, were grown in India. These had dark brown, almost red grains and the chapatis made from the flour were dark and unappetising. There were many complaints and so these dark wheats were crossed with traditional Indian wheats, such as Sharbati, to give new varieties, like Sharbati Sonora, which gave high yields, were medium in height and did not fall over, could be densely grown (thus giving more straw with which to feed cattle), and bore grains of the desired amber colour. However, some of these new crossed varieties still gave dark-coloured chapatis. This was traced to the activity of an enzyme called tyrosinase, which is present in rather large amounts; this enzyme oxidises polyphenolic constituents present in the bran and germ with the formation of dark-coloured melanoidin products. Incidentally the latter are actually related to the pigments that give our own skin its brown colour, and which is missing in leucoderma and in those born albino. Wheat varieties like Kalyan Sona, C-306, and C-308 were developed to yield chapatis of normal colour, and today there are yet others like Arjun, Janak, Pratap and WL-711.

Another rather intricate facet of chapati-making concerns the starch grains. Chakki-grinding of wheat is rather an abrasive operation and large numbers of individual starch granules get damaged.

Starch in the granule then becomes exposed, and an enzyme called beta-amylase that is abundantly present acts on the starch to release a sugar called maltose which imparts a slight but desirable sweet taste to the chapati. Further, damaged starch absorbs more water, which not only conduces to the release of sugar by the enzyme, but also gives a flexible dough that permits the chapati to be rolled really fine. The dough should be kept for some time for fermentation, but not too long, since the maltose will then be attacked by yeast with the formation of carbon dioxide, and the dough will go slack.

What causes the appetising smell of a freshly-roasted chapati? It arises from the same chemical reaction, the Maillard reaction, which we have already noted in considering the yellowing of parboiled rice. The first step is the reaction of proteins (and especially of one of its constituent amino acids called lysine) with reducing sugars (examples of these are glucose, fructose and the lactose of milk, but not ordinary sugar or sucrose), usually with some loss in nutritional value. Thereafter these initial products are further broken down in a variety of ways especially during heating to give brown-coloured compounds; these changes further reduce nutritional value, but also give rise to the appetising flavours and odours of cooking vegetables and meats, roasted coffee, roasted groundnuts, freshly-baked bread, toasted bread slices, and chapatis roasted on a really hot tava. Odours of these materials arise from a complex mixture of constituents, some of which have a nutty, roasted or baked odour, others a caramel or burnt sugar smell and yet others a pungent burning aroma.

The puffing of a chapati to a convex shape is caused when steam accumulates between the bottom and top layers of the wheat. Any break or weak point in the wheat layers will cause an escape of moisture and poor puffing; an even, continuous layer of dough must be present, and this will depend on the power of the gluten network to hold the wet flour in a continuous skin.

Traditional wheat products

Wheat that is specially broken, or emerges broken from threshing, is termed dalia and is used as a sort of boiled porridge. Like rice, wheat can also be puffed; the friable puffed product can be ground into a flour called sattu which being pre-cooked can be rapidly

finished into various foods.

String-like products include the delicately-drawn phirni, eaten with sugar and milk. A thin dough from the finely-ground flour of certain hard, yellow wheats is forced by hand or machine through dies, the product collected in coils as it emerges, and quickly dried to stiff, brittle strands. Vermicelli has thicker strands, and its long, straight lengths are packaged in bundles. The spaghetti and macaroni of Italy are indentical; the former is rather thicker and longer than vermicelli, while the latter takes the form of short, hollow tubes. All these pasta (paste) products cook quickly into soft elastic foods.

Originally made in the Middle East, and later in Europe and America, parboiled or bulgur wheat is produced by steaming whole wheat for a few minutes and then soaking in warm water for some hours, followed by draining and brief steaming again before drying. It can be used whole or ground into fractions, with the advantage over ordinary wheat of better keeping quality, nutrient value and taste.

Roller flour milling and its products

The 350 roller flour mills working in India in 1980 processed about 3.5 million tonnes of wheat, or about 10 per cent of production, the remaining 90 per cent being ground in traditional chakkis. Roller flour mills do not grind wheat by crushing, but by gradually and gently shearing the grain between two rolls, moving in opposite directions and at different speeds. The bran and germ are first separated between grooved rolls from the inner endosperm of the grain, which is thereafter reduced to flour between smooth rolls in a series of milling steps. After each operation, the flakes are scraped away from the rolls, and there is a sifting operation on what is called a plansifter to separate bran, endosperm, germ, and bran that still carries some attached endosperm: the first three are removed, and the last goes to the next set of rolls to separate more endosperm. Inside the system, the products are carried from one place to another in streams of air and once the operations have been adjusted to give the products required in their desired proportions, working of a roller flour mill becomes almost automatic. The bran and germ can be separated quite cleanly, and wheat germ, which like rice germ is rich in fat, protein, fibre, vitamins and minerals, is a valued product in

advanced countries. Sometimes the flour is further ground, and thereafter separated into fractions rich in protein or rich in starch in what are called air classifiers; these employ the principle of exaggerating slight differences in specific gravity between these constituents.

In India, three products are derived from wheat by roller flour milling. These are: 50 per cent of maida, 10 per cent of rava or suji and 40 per cent of resultant atta. These proportions can be varied quite a lot depending on the demand in the area; for example in south India a higher percentage of rava is produced since it is used widely to make uppuma. This is done by emphasising the operation at which the grain is broken up. Rava consists of granular wheat particles, and there are fine and coarse ravas for making various dishes. Maida is the white inner flour of the wheat with the least amount of constituents other than starch, and is the last product of the roller flour mill. Resultant atta is the most heterogeneous; after some of the bran and germ are removed, the endosperm with some bran still attached is ground up to give resultant atta. These three products have different destinations. Maida, sometimes called American flour by the housewife, mostly goes to the baking industries, and as we shall see, different wheats give maidas that are particularly suited to making bread, or biscuits, or cakes. Some maida is also used by halwais, restaurants and in the home to make sweetmeats. Rava is almost entirely for the use of the general consumer. Resultant atta is also a consumer product, sold in kirana shops and used in place of the more expensive whole wheat flour for making chapatis and other wheat products.

Table 1.3 shows the composition of and the nutrients in wheat flour and its roller mill products. These reflect their levels of the three basic wheat components, endosperm, bran and germ, whose characteristics had earlier been set down in Table 1.2. Maida is essentially the starchy endosperm, and has low contents of ash and crude fibre: there is less protein than in whole wheat but the proportion of gluten is higher because of segregation. It is also low in all vitamins and minerals. Rava is practically broken, polished wheat and similar therefore to wheat atta in nutrient terms, though perhaps a shade better. Resultant atta has endosperm, and some bran and germ; it is therefore nutritionally much better than maida, but the loss of bran and germ means that it is less nutritious than the whole wheat atta used to make chapatis.

TABLE 1.3

Composition of typical whole wheat Atta, Maida, Resultant Atta and Rava

	Whole atta	*Maida*	*Resultant atta*	*Rava*
		Figures as percentages		
Moisture	12.0	12.0	12.0	12.0
Carbohydrates	64.1	67.3	64.2	68.6
Protein	10.8	9.8	12.4	9.4
Gluten	7.9	9.2	7.1	8.0
Total ash	1.5	0.76	1.66	0.60
Crude fibre	2.2	0.17	2.10	0.45
Fat	1.5	0·8	2.5	1.0
Alcoholic acidity	0.15	0.10	0.17	0.10

Accordingly, the addition of nutrients to such resultant atta has been suggested. This was actually put into effect for a few years in the early seventies by some roller flour mills in Bombay, Delhi and Calcutta, but not any more. In the USA and UK, all flour is fortified with added nutrients and since bread is a staple food eaten in large amounts, such fortification has been credited with some dramatic improvements in health. The USA fortification level is now: thiamine 500, riboflavin 320, niacin 4000 and iron 3500, all expressed in micrograms per 100g, while optional additions are calcium 2000 milligram/100g and vitamin D. These levels of nutrients are about equal to or a little higher than the natural levels in wheat.

Kinds of wheat

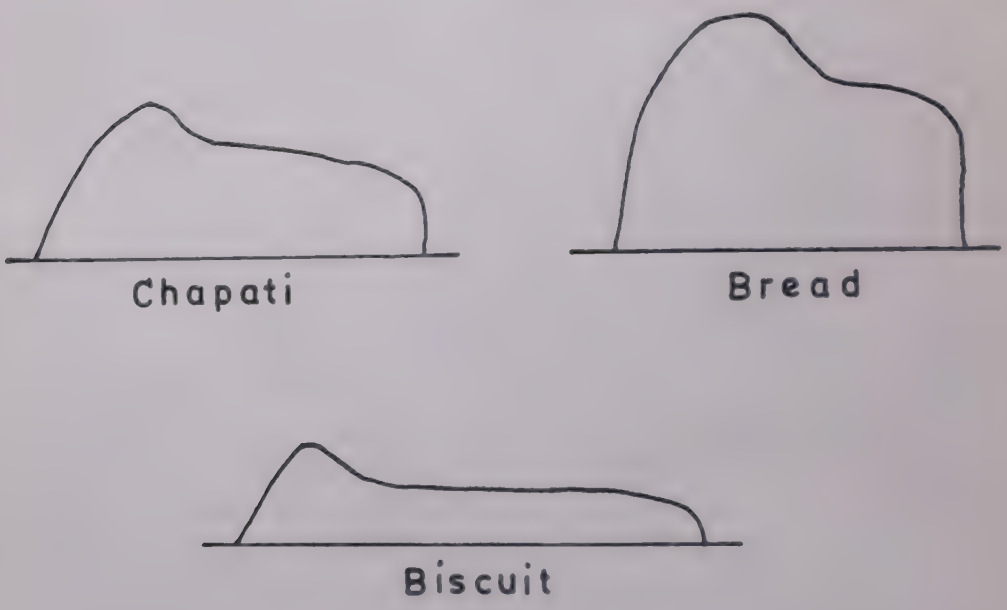
We are now ready to look into the nature of various wheats considered in regard to their utility. As we have seen, the qualities required for making chapatis differ from those needed for baking bread. Certain traditional, amber-coloured Indian varieties, at one time called sharbati in the trade, were well known to be particularly suited for chapati-making. These contrasted on the one hand with pissi or soft white wheats well adapted for grinding into maida, and on the other with dara wheats of medium-hard quality which were particularly employed to make dalia (broken wheat), rava (semolina) and so on. All these varieties belong to the aestivum species of the wheat (Triticum) family. There was also a small proportion of very hard wheats of the durum species grown in the black soil areas of central

and peninsular India; these hard varieties were excellent for making such drawn wheat products as vermicelli, and the finely-strung, precooked phirni of the north or peni of the south which taste so delicious with milk and sugar. Thus the traditional wheat varieties were well matched with long-standing food uses.

Both the growing popularity of western-style baked products, and the sudden introduction of high-yielding varieties with characteristics that differed from traditional ones, altered this status quo. The qualities needed for baked wheat products can be well illustrated by reference to the five major wheat varieties grown in the USA. Hard red winter wheat, with a high protein and gluten content, is used for breadmaking, sometimes mixed with even stronger hard red spring wheat. These types are not suitable for making biscuits or cakes, for which the so-called western white and soft red winter wheats are better. Durum, the very hard wheat, is uniquely suited to making semolina (which resembles rava), spaghetti and macaroni. Since even wheat varieties recently introduced into India have to cater largely to the requirements of making chapatis in the home, they are often not ideally suited to the different qualities needed for making baked products, especially bread. Doubtless specific varieties will be raised and reserved for specific use in future.

Wheat quality and baking

We have seen that the nature of the gluten determines the suitability of a wheat flour for making chapati, and the same is true for other baked foods. Suitability is determined experimentally by subjecting a well-conditioned ball of dough to stretching tests, and the results for flours suited to making chapatis, bread and biscuits are shown in the figure (p. 18). The bread dough is a strong one, with a large overall area signifying a stable dough, good height showing high elasticity, and medium width that reflects only medium extensibility. The weak biscuit flour has a poor elasticity or height, but is highly extensible. The chapati dough lies in-between, both in elasticity and extensibility. In another test that also measures dough strength, a ball of dough is placed in water: a hard bread dough will stay intact for nearly three hours, twice as long as a chapati dough. The viscosity of the flour suspension in dilute lactic acid, measured by resistance to the movement of a ball suspended in it using a special viscosimeter, is another way of determining flour strength, particularly



useful for biscuits and cakes. The level of the two amylase enzymes, together called the diastatic activity, is important in the fermentation of bread dough, but less important in making chapatis; the higher the enzyme activity, the less will the dough have to be worked to produce a good loaf of bread, while a tough gluten can be mellowed by adding extra enzymes. Another test related to enzymes is to determine periodically the viscosity of a flour suspension as its temperature is raised, which serves to indicate how much extra enzyme is needed. How much of the strach grains have been damaged during milling? An estimate of the quantity of maltose is a good measure of this. We have seen that a high maltose value is actually a plus point in making a chapati, but for bread, and much more so for biscuits and cakes, low maltose values are preferred. As an overall quick test of the baking quality of any sample of wheat, the proportion of flour that sediments out of a water suspension after a certain time is inversely proportional to wheat strength. For a more certain evaluation, before bread-making, a test bake under strictly controlled conditions to assess the loaf volume, appearance, crumb colour and crumb texture is carried out; blending of wheats can be adjudged accordingly. By a process of segregation of wheat flours in streams of air, protein- and gluten-rich fractions can be separated for mixing with wheats naturally low in these constituents. Even segregated gluten (sold in two forms, wet and dry) can be

used to improve the strength of flours deficient in gluten to enable their use in breadmaking. Thus when a dough shows an extension pattern similar to that for a strong dough, but small in area, it can be used to make bread if gluten-reinforced, and to bake chapatis if extended with a soft dough. A natural chapati dough can often be used to make good bread by adding a chemical improver like potassium bromate, which even in very small quantities toughens gluten to a remarkable degree, and also stimulates yeast activity.

Special flours

Self-raising flour is an intimate mixture of flour and less than 5 per cent of a mixture of sodium bicarbonate with one or more acidic substances like calcium phosphate, sodium acid pyrophosphate and sodium aluminium phosphate, in amounts which exactly match the alkalinity of the sodium bicarbonate. Baking powder is a concentrated form of the same mix in which the flour level is not 95 per cent but just 30 per cent. The main purpose of these flours, as their names suggest, is to assist in the quick chemical leavening or raising of dough for baking biscuits and cakes in the home.

OTHER CEREALS

Tough customers

Rice and wheat are classified as fine cereals, but we have in our country a number of coarse cereals or millets that are raised on poor soils. These have tough, fibrous outer layers, and yield rather coarse flours that may not appeal to those accustomed to rice and wheat, but do have local usage. If suitably processed using new methodologies, the textural properties of these millets can be turned to advantage in food formulations.

First let us consider jowar (cholam or sorghum). Grinding this whole in a heavy chakki gives a coarse flour that is used, especially in western India, to make the roti called bhakri. Dry shearing of the coarse outer layers of jowar leads to serious nutrient losses, but incipient surface wetting for a short period makes for easy abrasive pearling thereafter in an ordinary rice mill. Jowar flour makes an excellent dosai ingredient in place of rice, and gives a tasty chapati if hot water is used to make the dough. However, jowar grits or rava are difficult to cook.

Much the same is true of the other common coarse cereal, bajra (cumbu).

Maize (bhutta or makai) is being increasingly grown in India, mainly for use as an animal feed or for commercial starch production. In Mexico, wet-ground maize is cooked in lime water and left overnight to steep. The ground flour is used to make rotis called tortillas which resemble the rice chapatis of Coorg. Maize rava has a pleasant texture and flavour. The early white settlers in America called maize Indian corn, and corn flakes are made commercially from maize. After being well cooked under pressure, maize grains pass between heavy rolls which press them flat. The thin flakes are then dried crisp and toasted to develop a rich aroma. In fact the flattening in this way of many food materials that are difficult to cook, like coarse grains or whole dhals, is a technological means of achieving their quick cooking in the kitchen. The puffing of maize in hot air to give popcorn is now a common fun-food enterprise in India. Besides maize, jowar and bajra can also be puffed to give products of a porous, crunchy texture and agreeable flavour. The ground flours of both maize and bajra have been found particularly appropriate for making snacks like murukku, chakli, khara sev and thengole which are deep-fried to crisp products.

Ragi or nachna, the small round cereal with a purplish coat, is common in Karnataka and in Maharashtra. The product is soaked, sprouted for a couple of days, dried, and ground with a little salt and pepper into a powder which is employed either as a porridge for young children, or in the form of steamed balls by the rest of the family. Germinated ragi powder is also commercially available under various brand names for use as a beverage or breakfast porridge. Ragi can be milled in much the same way as wheat.

Barley (jau or job in Hindi and Bengali) is shorn of its outer layers to expose the inner white endosperm, and marketed as pearl barley. Nutritionally this has little in it but starch, which gets solubilised when barley water is prepared. Barley has a much bigger outlet in the manufacture of beer and whisky, as described in Chapter 12.

Nutrients in coarse grains

Table 1.4 compares the composition of five coarse grains with that of wheat. All are remarkably similar, except for a slightly lower

TABLE 1.4

Nutrients in Coarse Grains compared with Wheat

	Wheat	*Jowar*	*Bajra*	*Maize (dry)*	*Ragi*	*Barley*
			Figures as percentages			
Moisture	12.0	12.0	12.0	12.0	12.0	12.0
Carbohydrates	65.6	72.6	67.9	68.8	72.9	70.1
Protein	10.8	10.4	11.6	11.3	7.4	11.5
Fat	1.5	1.9	5.0	3.6	1.3	1.3
Crude fibre	2.2	1.6	1.2	2.8	3.7	3.9
Total ash	1.5	1.6	2.3	1.5	2.7	1.2
			Figures as micrograms/100g			
Thiamine	350	370	330	420	420	470
Riboflavin	160	130	250	100	190	200
Niacin	5,400	3,100	2,300	1,800	1,100	5,400
			Figures as milligrams/100g			
Calcium	45	37	42	10	344	26
Iron	4	6	5	2	6	3

protein content in ragi (though still higher than in rice, which has about 6.4 per cent protein) and the comparatively high fat content (5.0 per cent) of bajra against about 1 to 2 per cent in the other cereals. Very striking however is the exceptionally high calcium level in ragi, 344mg/100g against values of 10 to 40 mg in the other cereals. Since growing children need calcium at the age when their teeth and bones are being formed, ragi has excellent possibilities in making foods for weanling and older children; moreover it seems to favour an alkaline balance in the body, and has an exceptionally pleasant taste after sprouting and roasting.

Sago

Sago or sabudana comes as small white pellets which cook to a sticky, translucent mass that looks and tastes nice, but nutritionally is almost nothing but starch. The semi-transparent look after cooking is dependent on the starch that has been used to make the granules. Sago that is made from rice, wheat, jowar or maize not only cooks slowly but yields an opaque product that looks rather like

cooked rice. It is only the starch from various roots and tubers, such as the tapioca that is used in India, or the pith from the stem of the sago palm that was traditionally employed in Malaysia and Indonesia, that gives the desirable translucent appearance and stickiness.

In Tamil Nadu and Kerala, tapioca roots are peeled and washed, and then disintegrated in water using saw-like raspers working in a steel drum. The tapioca milk that comes out is run over long cloth sieves placed on setting tanks, when only the finest starch particles pass through. These are allowed to settle, dried in the sun and forced through coarse metal sieves. The small granules thus formed are put into wooden trays lined with cloth and given a circular motion; the granules stick together and build up a round shape. They are then gently heated so that the surfaces will gelatinise and harden, and dried in hot air. Uniform gelatinisation is necessary to ensure that the sago granules do not stick together, both during manufacture and later during cooking. Finally the granules are dried in the sun.

Nutritionally sago is a source of starch-based calories, some 350 to a 100g. It is 87 per cent starch and 12 per cent water, leaving room for just bits and pieces of protein, fat and minerals, and no vitamins.

DHALS AND GRAMS

In advanced countries, the terms legumes or pulses include lentils, peas and beans. In India, the term gram denotes mainly the lentils; and for split grams, the word dhal is used. Dhals are an important item of food, and are used in a vast variety of forms. They may be cooked into thick or thin gruels, or combined with cereals in diverse ways to give khichdi, idli, dosai, vada and dahi vada, murukku, dhokla and puran poli. Grams may be germinated or fermented, roasted, puffed or fried. Flours like besan, made from the Bengal gram, are an important batter for deep-fried snacks, and even a base for sweets like mesur pak.

India boasts of an enormous number of grams. We have in everyday common use the Bengal gram (chana, chickpea), tuvar or arhar dhal (red gram, pigeon pea), mung dhal (green gram), masoor dhal (lentil), urad or mash dhal (black gram), kulthi (horsegram) and kala tur (Indian soyabean). Other less-common legumes are

the rajmah (kidney, haricot or French bean), avare or valpapdi (field bean), bakla (broad bean), chastang (double bean), mattar or pattani (green pea), babril (pink beans), lobia (cowpea), kheri (moth bean), satari (rice bean), sim (scarlet runner bean), guar (cluster bean), bara sim (sword bean) and groundnut (mung phali).

Some part of the harvested grains is processed in the home. But being important volume products, they are also served by some 10,000 traditional chakkis that use animal power and about 1000 units driven by electrical power. Let us look into the technology of our many grams.

Two bits from one

Grams are mostly eaten after splitting them to dhals, and this also implies that the seed coat is removed. Two methods are used. In the dry method, the grains are dried in the sun, sometimes after sprinkling with a little water, and then pounded in a wooden, iron or stone mortar with a heavy pestle, after which the husk is winnowed away from the split pieces. Inevitably a good deal of brokens is generated. Grinding in a chakki between rotating stone or wooden plates operated by hand or power is a more sophisticated, dry, village practice. The wet method is particularly used for grams like tuvar in which the husk is rather strongly attached by a gummy material to the inner dhal. The gram is soaked in water for several hours, mixed with red earth and dried in the sun for 2 to 4 days, after which it is milled either by pounding or chakki-grinding. Grams like urad and mung are mixed with a small amount of linseed or castor oil, dried in the sun, mixed again with some abrasive stone powder and dehusked in a chakki. In all styles of chakki-grinding, any unhusked grains from the first pass are separated, sometimes sun-dried, and put again through the chakki to give a dhal of second quality. In some instances the outer husk on the whole gram may first be scratched or pitted by passing it through a suitably-spaced roller before applying oil, so as to facilitate penetration. All these traditional practices achieve both husk-removal and splitting in a single operation.

A major drawback of them all is the rather high proportion of brokens. These pass into the skins or chuni, which is used for feeding poultry and livestock. Brokens reduce the yield of cleanly-split

dhal, and modern improved processes proceed stepwise. To loosen the husk and make it brittle, the gram is first treated with warm air to reduce its moisture level, and then put into a conditioning bin through which ordinary air is drawn. This is continued till the gram has built up the right level of moisture (this varies with each gram) for effective dehusking, which is then effected by an abrasive scouring or pearling operation between stone-coated rollers.

Grams have a gummy layer between the hulls and the inner dhal which seems to differ in each gram. In consequence, the abrasion pressure, rate of feeding the whole gram, and the clearance between the rollers need to be adjusted for each one of them; when this is done, almost total hull removal is effected. Later, in a separate operation, whole gram can be split very easily by slight pressure into two pieces of dhal.

Gram-based products

A great many grams are bought in the market in the form of split dhal. A few processed grain products are also made on a large scale, and we may examine the technologies involved.

Besan: This is the flour of the Bengal gram or chick pea. The dhal is put out in the sun to dry, and while still hot it is ground in a stone flour mill, sometimes twice over to achieve fineness. So much frictional heat is generated that the besan emerges really hot and needs to be cooled. In hotels and large establishments, the dhal is ground in water to get a thick or thin batter.

These doughs, suitably salted and spiced, can be extruded through dies into a bath of hot oil to give various deep-fried snacks, such as crisp sev, murukku and thengole, and softer jangree and laddu. The reason why only Bengal gram and black gram (urad) are used for these snacks lies in their exceptionally glutinous nature, which leads to excellent moulding, extruding and binding qualities. The use of besan batter for deep-frying of pakodas and bajjias is based likewise on the exceptional crispness of the finished products, which other gram powders simply will not confer.

Puffed grains: We have seen that rice, wheat and corn can be puffed. The Bengal gram is also puffed in India, and cowpeas (lobia) in other countries. While cereals puff to 8 to 10 times their volume, the Bengal gram expands just one-and-a-half times to a product of light, porous, crunchy texture and pleasant nutty taste. To puff it,

the gram is warmed, moistened with just a little water and then toasted on hot sand, when the capsule bursts. and the husk is easily rubbed off. In large operations today, heated revolving cylinders carry the hot sand, and the operations are largely mechanised and carried on continuously. Puffed Bengal gram is itself a snack but is also an ingredient for blending into other snacks. Crisp blends are made using parched rice and extruded sev, and puffed Bengal gram is rolled into laddus with jaggery syrup. Both the digestibility and nutritive value of puffed Bengal gram are high.

Prepared mixes: Dhals are used in the southern home as the base for making such foods as rasam, a thin soup, and sambhar, a thicker one. In making commercial instant mixes for such products, attention must be given to precooking and then dehydrating the dhal so that it will reconstitute almost instantly when boiled with water. Care is also needed in precooking and then drying any vegetables used, ensuring that the spices employed (chillies, methi, mustard seeds, asafoetida, coriander, turmeric) have the right roasted flavours, and making sure that the packaging is such that the mix keeps dry and does not alter in flavour. Well-made products can be of excellent quality and offer great convenience, but will of course lack the personal element in spice blending on which the Indian housewife prides herself.

A chakli mix needs rice flour, dhal flour, spices and fat, and each must be processed separately in an optimum way before blending. It is not uncommon to fumigate these mixes before packaging to improve their keeping quality.

Another class of instant mixes are those for the familiar southern fermented products, idli and dosai. These are traditionally made by grinding together broken rice and urad dhal with water for a prolonged period, followed by overnight fermentation through the agency of the natural enzymes present. The idli is a steamed product derived from a thick batter, the dosai a shallow-fried pancake from a thinner one. Ready mixes for these save the housewife hours of grinding and fermentation. The principle is the use in the right quantities of leavening agents like baker's yeast or baking soda (sodium bicarbonate) to generate carbon dioxide gas and thus bring about the right porous texture, and of acidifying agents like citric acid for both taste and flavour. It is also important that the rice and dhal ingredients are ground to a certain degree of coarseness or fineness to impart the

right mouthfeel to the cooked products. Complex chemistry and biochemistry lie behind this fermentation. Though rice does contribute some microorganisms, it is the urad dhal that has the key role. To begin with, it donates most of the microorganisms which cause the production both of carbondioxide gas and of materials with an acid taste. Also, it contains a gummy material which stabilises the foam created by another protein component; these act together to hold in thrall the fermentation gases which contribute to the rising of the batter and to a porous structure after steaming. Many other dhals have been found to carry the foaming principle, but do not have the gummy stabilising constituent, and will not therefore ferment in the proper fashion.

The gums that exist in a dhal between the husk and the inner body thus play a part both in the fermentation process and in the dehusking of the gram. In one pulse, the guar phali or cluster bean, this gum actually makes up as much as 40 per cent of the bulk, with the dhal proper constituting another 45 per cent and the husk the remaining 15 per cent. Guar gum has exceptional properties, which give it industrial importance both in food industries as an emulsifier, thickener and stabiliser, and in non-food industries like paper-making, textiles, ore-floatation and even petroleum drilling. The guar beans are first heat- or sun-dried, split in roller or sheller machines, and the husk then removed, after which simply the ground powder itself constitutes a gum preparation. Increasing the gum purity yields various grades, leaving behind a high-protein residue that is a valuable cattlefeed. Guar gum is made and exported in enormous quantities from India.

Proteins in capsules

Dhals are the sheet anchor of protein nutrition in India. They can be bought for one-fifth the price of mutton, and yet they carry 23 to 27 protein against the 18 to 19 per cent level in meat. It was usual at one time to rate eggs, meat and milk as superior proteins because of both a better balance of the eight essential amino acids, and of high levels in them of two of these amino acids, lysine and methionine-plus-cystine, which are frequently limiting in total diets. All dhal proteins are exceptionally rich in lysine, several of them being even better-stocked in this regard than the soyabean, whose protein quality is so

much advertised. On the other hand, cereals like rice, wheat, bajra, jowar and ragi all carry proteins with adequate levels of methionine-cystine, but rather lacking in lysine. So when cereals are eaten along with dhals, there is a reinforcing effect: as a result the quality of the total protein, that from the cereal and that from the pulse, is raised to a level very close to the protein of milk or meat. If marks were to be given, milk and meat proteins would score 70-72 out of a total of 100 : cereal-dhal combinations would approach 60-65. This is a reassuring fact of life in regard to everyday protein nutrition in India.

Dhals bring other nutrients into our diet, of which the three B-vitamins, namely thiamine, riboflavin and niacin, occur at levels of about 0.45, 0.20 and 2·50 milligrams in a 100 g of dhal. These quantities represent roughly a third, a sixth and an eighth of the daily requirement of an adult. Thus dhals are useful in supplementing the intakes of these vitamins from cereals, which are much larger since cereal consumption is itself 10 to 15 times greater than that of pulses. Most dhals carry, in every 100g, some 3 to 5 mg of iron (about a tenth of the requirement) and 70 to 150 mg of calcium (about a fourth of the requirement). Unlike rice polishing or wheat milling, processing grams to remove the husk does not whisk away these nutrients since they occur in the body of the gram and not in or near the skin.

Many pulses (especially beans rather than grams) carry what are called anti-nutritional factors. One is a substance that causes red blood cells to stick together, and so it is called a haemagglutinin. Another material in raw dhals conduces to enlargement of the goitre, and is called a goitrogen; its effect is further aggravated by the low iodine content of most dhals. A third is anti-trypsin, which hinders the enzyme trypsin from digesting proteins. Frightening as the facts may seem, luckily all these anti-nutritional factors are present in very small amounts, and are totally destroyed when the dhal is cooked, so that no harm accrues in practice. In fact it has been shown that cooked dhals can be mashed and safely given even to children after they are a year old, especially if supplemented on nutritional grounds with a little milk to provide methionine-cystine.

There is, however, another drawback of dhals as food, and this has to do not with the protein but with the carbohydrate. When the carbohydrate consists of starch, or of sugars like sucrose, glucose, fructose, maltose or galactose, the digestive enzymes can break them

down without difficulty to furnish the body with energy. But three sugars with rather pretty names, verbascose, stachyose and raffinose, present in pulses are not easily mobilised in this way. Accordingly they find their way into the large intestine where the microorganisms present ferment them to give rise to gases. These can cause discomfort and even pain, and when ejected, an unpleasant smell. Mung dhal or green gram produces the least gas, and is therefore preferred for child feeding. Next come tuvar and urad, while Bengal gram is most prone to gas-formation. Sprouting for 48 to 72 hours reduces these troublesome sugars to a quarter or less of their original value, and so does fermentation, as in idli-making.

Another anti-nutritional constituent present in most grams is called phytate, a compound carrying phosphorus. Phytate is a bit of a nuisance, because it ties up metals like calcium, iron, magnesium and zinc, and prevents them being absorbed from food by the body. Where there is enough of the mineral in the diet, as with say calcium, this may not matter, but for the other minerals, whose content in dhal is often low, the position could be more serious.

Every housewife knows that all grams take time to cook, and some, like rajmah, lobia and Bengal gram, are usually soaked overnight to soften them. Food technologists have devised methods to prepare dhals in such a way that they can be cooked much faster. One method is by first softening the pulse, flaking it into a thin disc, and then drying. Another approach is to steam the husk so as to detach it from the dhal inside. Abrading or scouring the skin is yet another, and so is a technique to weaken the skin by getting certain protein-attacking enzymes to work on it. All these procedures of course add to cost, and since grams are daily items used in fair quantity, this becomes an important factor in retarding the commercialisation of these quicker-cooking products.

CHAPTER 2

Oily Business

Vegetable Oils, Vanaspati and Margarine

MOST OF US keep liquid cooking oil in the kitchen, or we use vanaspati, which is solid. In common speech, a liquid material is called an oil and a solid material a fat. A scientist uses the term fat to refer to both. Fats are one of the three major classes of nutrients in food, the other two being carbohydrates and proteins. In this chapter the word fat refers to both liquid and solid materials.

The historical development

All the world over, fats of various kinds have been used for cooking from time immemorial. In countries of the West, it was usual to get cooking fat from animal meats. Streaks of fats are found in all forms of meat, giving it a marbled appearance, and beads or bundles of fat, called charbi in India, occur too. If charbi is boiled with water, the fat bursts from these bundles and floats to the top. On cooling, this fat solidifies and can then simply be picked out. When such fat comes from goat or sheep mutton it is called tallow, and lard when derived from pig meat or pork. Solid fats like tallow and lard were the chief cooking media for Western people, and for the Chinese and the American Indians, till quite recent times.

India took a different route, and our fats have mostly come from vegetable oilseeds. The earliest of these seem to have been sesame (til or gingelli) seeds, mustard (sarson) seeds and, especially along the coastline, the flesh of the coconut. Usage of these oils appears to have predated even the Indus valley civilisations, which have been placed at about 2000 B.C. In fact since ancient times the only major addition to these traditional oils has been the groundnut, which was brought to India by the Portuguese traders who followed Vasco da Gama in the sixteenth century. Today the groundnut is our major oil,

constituting over half the total production of all vegetable oils. Next comes mustard oil, followed by the safflower (kardi or kusuma) and the niger (ram til).

All these are liquid oils, but India had a solid fat of great importance in the form of ghee. This could have been evolved following the Aryan influx, which occurred in waves over the first millenium B.C., because it was they who first domesticated cattle. Many reasons contributed to the popularity of ghee: an attractive smell, taste and feel; the virtues of a solid fat in creating the layery texture essential to foods like chirotti and mesur pak; association with the sacred cow; and easy and complete digestibility even by children. Ghee held pride of place in the Indian cuisine whenever it could be afforded. The alternative was vegetable oil. We shall come back to ghee as a dairy product in Chapter 3, and talk about vegetable oils here.

Making and using traditional oils

Liquid oil is traditionally obtained from an oilseed by the exertion of pressure in a ghani or kohlu. This consists of a cylindrical vat or mortar, made of wood, stone or iron, in which a stout wooden pestle or arm-yard is rotated through the agency of a draught animal walking around in a circle. The seed is fed into the mortar and moistened intermittently with water; the friction caused by the continuous slow movement of the pestle warms up the seed, and the pressure exerted between the pestle and side of the vessel squeezes out the oil. It is believed that the oil is displaced by water in the operation. From seeds rich in oil, like the groundnut, mustard and sesame, three-fourths or more of the oil present can be obtained by crushing in a ghani.

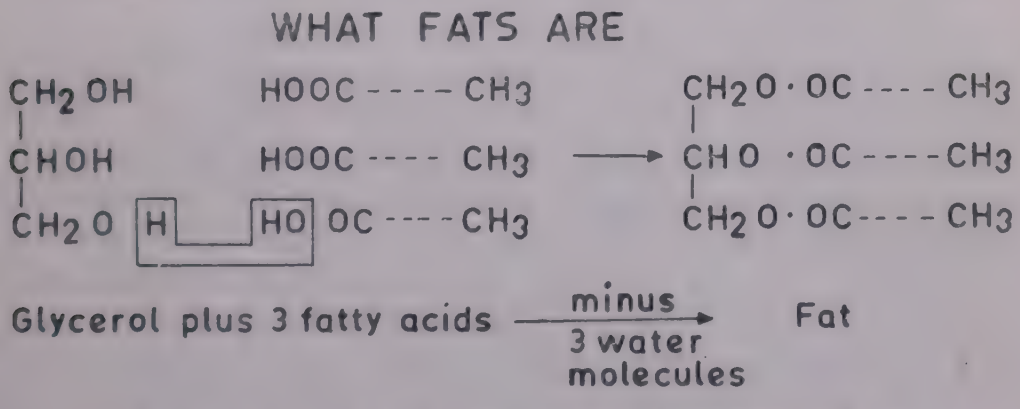
Another method, used for making oils in the home rather than on a large scale, is to boil the crushed oilseeds with water, when the oil floats to the top, and can be skimmed off. Coconut oil in particular is often made in this way from fresh coconut meat or dried copra.

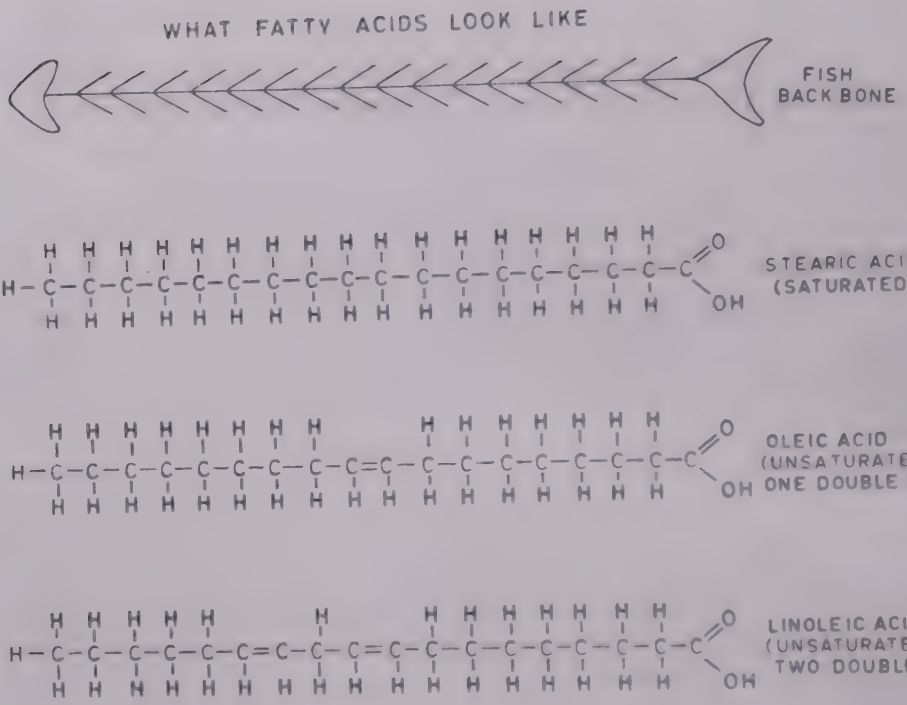
Traditional oils won by such methods were used in the form in which they were obtained; thus the flavouring and colouring matters native to the oil remained. In turn this led to rather strong regional preferences for certain local oils. Coconut oil, with its distinctive perfume odour, was prized in Kerala. Mustard oil made in a ghani has a strong pungency. The compound chiefly responsible

for this flavour is called allyl isothiocyanate. It is present in the seed in a bound form, from which it is released by an enzyme, also lying dormant in the seed. This happens in the ghani during the slow grinding operation, when moderate heat is developed : in fact, the conditions of wetness and warmth are almost ideal for such enzyme reaction. The more pungent the mustard oil, the better is it relished for cooking purposes in Bengal, Uttar Pradesh, Punjab and Haryana. Sesame oil has a nutty natural flavour and excellent keeping qualities; it has always been a prized oil in many parts of India, particularly in the south, where one of its names is "sweet oil".

The innards of fats

All oils and fats are combinations of what are called fatty acids with glycerol. Glycerol is nothing but the familiar glycerine, and it has three prongs in its chemical structure, like a trident. Fatty acids are like the backbone of a fish (see figure on p. 32). There is a string of carbon atoms, to which are attached hydrogen atoms. The tail end carries an acidic or carboxyl group. Three such fatty acids are attached by these carboxyl tails to the three prongs of glycerol. There are a number of fatty acids, but four are very commonly found, and the difference between one fat and another lies simply in the relative amounts of these. Two common fatty




WHAT FATTY ACIDS LOOK LIKE
FISH BACK BONE
STEARIC ACID (SATURATED)
OLEIC ACID (UNSATURATED, ONE DOUBLE BOND)
LINOLEIC ACID (UNSATURATED, TWO DOUBLE BONDS)

acids are palmitic and stearic: the first has 16 carbons in the backbone, the second 18. And in both the carbons are totally filled up with hydrogen atoms, so these fatty acids are called saturated.

In two other common fatty acids, there are unfilled spaces : one unfilled space means that two hydrogen atoms are missing. This is denoted by a double bond, and if present it denotes unsaturation. There are two very common unsaturated fatty acids. Oleic acid has one double bond right in the middle of its 18-carbon backbone; linoleic acid has two such double bonds, one right in the middle, and the other further along the backbone away from the carboxyl tail. The illustrations will make this clear. A solid fat like coconut oil or ghee has more saturated and less unsaturated fatty acids, and even the unsaturated acids are likely to be mostly oleic rather than linoleic. A liquid oil will have a high proportion of both unsaturated acids, but the proportions of oleic and linoleic acids will differ from oil to oil.

Why are oils refined ?

A fresh oil, newly-made by crushing fresh seed, will have all the fatty acids tightly bound to glycerol: but if the seed is old, or if the

oil is kept for a long time, some fatty acids get broken away from glycerol through the agency of either moisture or enzymes, a process that is speeded up by air, heat and light. These free fatty acids have both a smell and a taste; even more serious, they are quickly attacked by the oxygen in the air and broken down into smaller fragments which have very strong, rancid smells. This is the basic cause of rancidity of fats, and of foods containing fats.

Natural oils usually look yellowish, as a result of coloured materials carried over from the oilseeds. All our traditional edible oils, til, mustard, coconut and groundnut, are coloured, some, like the mustard, more strongly than others. Even oils which are not used for cooking have yellowish-brown tints, such as castor oil, which is both a purgative and a lubricant for the wheels of village carts, and linseed oil, that is used to make paints. Certain of the new oils have rather pronounced colours. Soyabean oil is greenish-yellow, and also carries a strong beany or bitter flavour. Cottonseed oil is jet black in colour, rather like used motorcar engine oil.

It is obvious that these newer oils cannot be used for cooking in the form in which they are obtained. They will have to be upgraded. This is done by a triple processing procedure of refining, bleaching and deodourisation that removes colour and flavour from vegetable oils. Since such bland oils have now become popular, it has also become the practice to remove colour and flavour even from oils like the groundnut. Oils like the mustard, coconut and til are still preferred in raw form, but they can also be refined in the same way.

In the refining process, the oil is mixed with a solution of an alkaline substance, usually caustic soda (sodium hydroxide), and the two are thoroughly mixed together in huge vessels. The free fatty acids present combine with the caustic, which also picks up some of the colouring matters. When the caustic solution is run off, the resulting oil, after washing once or twice with hot water, is devoid of free fatty acids, and has also lost a good deal of its colour. To further remove the colour, the oil is next heated up with small quantities of certain materials which attract and absorb the residual colouring matters. One of these materials consists of special kinds of natural earths; these are activated by treatment with acids and heat so that they develop this property of colour absorption. The second kind of bleaching substances are certain

types of charcoal, such as those derived by igniting pine woods, coconut shell, certain kinds of coal, and lignite, all of which can be specially activated so that they gain this colour-absorbing ability. In the actual bleaching operation, the refined oil is heated up and thoroughly mixed with these activated earths and carbons; the oil is then filtered, when most of the colour will have been taken away. Even now the oil carries a flavour and is not completely bland. This can be achieved by a process called deodourisation. that is, odour removal. The oil, already refined and bleached, is spread out in very shallow dishes; steam at high pressure is passed through the oil, while a low pressure or vacuum is simultaneously put into effect. The compounds which confer odour are carried away by the steam, and the resulting oil is both water-white and odourless.

Final incorporation of tiny amounts (0·05 per cent) of synthetic chemicals called antioxidants greatly delays the onset of rancidity in refined oils, but such addition requires special permission in India.

Hydrogenation

Hydrogenation is a process in which a liquid oil is gradually hardened into a solid fat. To understand why this happens we must go back again to fatty acids. We recall that these have a carboxylic group, which is at the tail-end of a long chain of carbon atoms to which are attached hydrogen atoms.

If a liquid oil is to be made solid, the unsaturated acids, particularly linoleic, will have to be saturated by adding on hydrogen. At the same time, oleic acid should not be saturated: it then becomes stearic acid, and this might make the fat too hard. Not just that : the hydrogenated product will not melt in the mouth instantly. This leaves a most unpleasant greasy sensation: you may have experienced this feeling when putting into your mouth from the refrigerator a sweetmeat like mesur pak or halwa (in making which solid fats are used). The hydrogenation operation essentially does just what is required: it saturates one of the two double bonds of linoleic acid, and hardly saturates oleic acid to stearic. Overall the fat is hardened.

Suppose one were to take the refined oil in a large vessel and heat it up. If the gas hydrogen is now bubbled through the oil, it will not saturate it: something is required to pick up the hydrogen

and transfer it to the unsaturated double bonds. This is achieved through the use of a catalyst, which consists of very minute particles of nickel spread thinly over a kind of porous material. This support material bearing the catalyst is uniformly suspended throughout the mass of the oil, assisted by a stirrer with paddles on it which keeps revolving all the time. Gradually the liquid oil gets harder, and this is allowed to go on till the melting point has risen to 37°C, which is just slightly below our body temperature. The fat is then drawn out from the vessel. The catalyst-and-carrier are filtered away through several canvas cloth frames, fitted together side by side in what is called a filter press. As a last step, the hydrogenated oil is once again deodourised so as to remove trace odours which may have developed during hydrogenation.

In India, it is necessary by law to add certain things to the hydrogenated product thus made. Since vanaspati physically resembles ghee, it could be used for adulteration of the latter. To prevent this, 5 per cent of til oil is added; this is because til oil answers a certain colour test which can be carried out in the laboratory. Hence its presence, and in turn that of vanaspati in ghee, can be detected. To improve the nutritive value of vanaspati, it has been made compulsory to add to it roughly 760 micrograms of vitamin A per 100 grams, so that using this quantity of vanaspati can be expected to give an adult his total needs of vitamin A, which is 750 micrograms. In practice, this vitamin A is rather rapidly destroyed on storage and during cooking, and it is doubtful whether most of it is actually consumed by the user. If the manufacturer wishes, some vitamin D may also be added. These vitamin additions are displayed on the tin.

Another step was taken more recently to improve the nutritional quality of vanaspati. The hydrogenation process, as we have seen, brings down the linoleic acid level, and in the hydrogenated product there may be just about 2 to 5 per cent of the acid. Linoleic acid is essential for the body: it cannot make this acid on its own, and the food must supply it. The acid plays many important roles in the body. For one, it keeps the skin supple, especially in babies (the fat present in breast milk carries the acid in fair proportion, but the fat in cow or buffalo milk, and therefore in baby foods made from them, is rather deficient in linoleic acid). Another function of linoleic acid has to do with atherosclerosis. In

this ailment, scales are deposited on the inside lining of the blood vessels; this clogs them up, and when in consequence insufficient blood reaches the heart muscles, they may tend to fail. There is a fair amount of evidence to show that the use of liquid oils rich in linoleic acid, like safflower, til, cottonseed and groundnut, plays a part in suppressing the formation of such scales on the blood vessel walls. How much of such linoleic acid is needed every day is rather difficult to determine. But since vanaspati contains so little, the decision was made to add to it, apart from 5 per cent of til oil, another 5 per cent of a liquid oil, like til oil itself or safflower oil, which is rich in this acid. As a result the finished vanaspati which goes into the tin and is bought and eaten by us will contain something like 7 to 10 per cent of linoleic acid.

Recent work has brought new evidence of the importance of linoleic acid. In the body the acid is transformed into complex compounds called prostaglandins. Every organ in the body makes its own kind or kinds of prostaglandin, and they seem to have tremendously important functions. Prostaglandins regulate blood pressure, and play a part in contracting our muscles and in blood clotting. They seem to be involved in the transmission of messages along the nerves to the brain. They are implicated in fertility, and in the proper conception and normal delivery of children. It does seem prudent therefore to ensure a good supply of linoleic acid, which are the sources of prostaglandins, in the fat which we use in our kitchens or at table.

Choice of fats for cooking

Vanaspati, even after adding some liquid oil to it as is now done compulsorily, can hardly be called a rich source of linoleic acid. Neither are oils like coconut and mustard. Coconut oil has in fact a lot of saturated fatty acids in it, because of which it turns solid in the winter months. Those who use it as a hair oil have experienced the nuisance of having to melt the contents in cold weather to get the oil out of the bottle! The linoleic acid content of coconut oil is just 2 per cent. Mustard oil, though liquid, has in it only 15 per cent of linoleic acid. It contains moreover a very large amount, over 40 per cent, of an unusual fatty acid called erucic acid. This has a 22-carbon backbone and only one double bond. In animal experiments, erucic acid seems to infiltrate the heart muscles and

settle down there, making them less elastic. However, autopsies on the hearts of those who have eaten nothing but mustard oil do not seem to show anything unusual, so perhaps the human body is not affected by erucic acid. Ghee also has just about 2 per cent of linoleic acid, and a lot of saturated acids besides; yet it has a very high image as a cooking fat in India.

For certain flavouring purposes, these unrefined oils are rather important in the Indian cuisine. A Kerala aviyal preparation without the flavour of coconut oil would lose its appeal, as would banana chips fried in any other oil. Lacking the pungency of mustard oil, a Bengali fish or prawn curry would be a dull dish. The flavour of ghee on chapatis, or on certain sweetmeats, or in a pilau is something to cherish. For baking cakes, the use of vanaspati, or better still of a special hydrogenated fat called a shortening, is essential for lightness and texture. It would be a pity to give up these delights of the palate.

Nor need we. It is the exclusive use of these fats that might bring us to grief. All we need to do is not to stick only to these fats, but to use liquid oils rich in linoleic acid for much of our general cooking. Safflower oil, otherwise called kardi or kusuma, is among the richest of these, with about 70 per cent of the acid; next follow cottonseed oil with about 50 per cent of linoleic acid, til oil with 40 per cent and groundnut oil with about 20 per cent. Sunflower oil, a new entrant to India, is likely to carry about 50 per cent.

Palm oil has about 10 per cent of linoleic acid, and palmolein about 12 per cent. What are these recent entrants to the ranks of vegetable oils ? Palm oil is pressed from the fruits of the oil palm, a tree of the coconut family. This is being cultivated in Malaysia on a huge scale, and the oil is obtained in very large quantities. India is importing it to meet the shortage of oils in the country, just as we have earlier imported soyabean oil from the USA, rape/mustard oil from Canada and sunflower oil from the USSR. Palm oil is cheaper than any of these. It has long been used for cooking in Africa and Malaysia, even though it may be new to us. One technical problem with palm oil is that it tends to solidify rather easily, and this causes difficulties when it has to be unloaded from ship tankers. To overcome this, the more solid portions are re-

moved from palm oil, and the liquid portion called palmolein can be shipped without difficulty.

The nutritional angle

We are well into nutrition already through linoleic acid. How much fat do we need every day? No one is quite sure, and even the Indian Council of Medical Research, which arbitrates these matters, does not give an explicit figure. What they do suggest is that, in a balanced diet, about 18 to 20 per cent of all the calories should come from fat. This means that an adult man, of moderately active habits, needs about 45 grams of fat a day and a woman about 40 grams; adolescent children need similar quantities, and a 5-year old child could do with about 25 grams of fat. Higher quantities than these are probably best avoided, but lower amounts do not seem to cause harm.

Fats give us lots of calories. For each gram that we eat, carbohydrates and proteins only furnish 4 calories, but fats provide 9 calories. Fats can therefore be called calorie-dense foods. An important fact is that all fats give us the same number of calories. So it doesn't matter, calorifically speaking, which oil or fat you decide to use; your choice will not affect the amount of energy you get from the fat. Neither are smell and taste relevant to nutritive value. The characteristic flavours of various oils are caused by the presence of very small quantities of associated substances which have no intrinsic nutritional qualities. The latter reside totally in the fat itself. Switching from a flavoured oil like coconut or mustard to a liquid oil or to vanaspati or to ghee will lose us nothing as calories.

Apart from being carriers of the important linoleic acid, fats in food give one eating pleasure: a fat-free diet is awfully dull and unappetising. Fats also give one a pleasant feeling of fullness or satiety after a meal, partly because the presence of fat delays the emptying of food from the stomach into the lower digestive tract.

Fats in food act as carriers of the fat-soluble vitamins. Vitamin A is one of these; some fats like ghee carry a certain small quantity of vitamin A, but vegetable oils have none. Vitamin D is also soluble in fat, and shark liver oil and cod liver oil are very rich in this vitamin. Vitamin E is also carried by fats; rats need it, but how far it is really necessary for human beings is in some doubt.

The role of fats as carriers of even these fat-soluble vitamins does not seem important to us in India. We get our vitamin A mostly in another way. A yellow substance called carotene (named after carrots, which carry it) is present in many vegetables and fruits; when we eat these, carotene is converted by the body into vitamin A. The other fat-soluble vitamin is also made in the body: the skin contains a substance which is converted into vitamin D when sunlight falls on us, and this substance we get from many vegetarian foods.

Apart from giving us energy, fat is also the form in which the body stores excess energy: putting on fat is a sure sign that one is eating more than one should. In a few people, fat accumulation may be compounded by imbalances in the working of the body. Fats occur as a layer below the skin, and play a part in keeping the body at a constant temperature. Layers of fat are found as cushions on bony projections, or enveloping certain organs like the kidneys. When a body is under stress, such as in fasting, fats help to increase resistance. Our capacity for sustained work is also improved when we eat enough fat.

Margarine

Margarine can hardly be called a food in India, so small is its consumption, but in the West it is rapidly displacing butter from the table, because of the reluctance of people to eat a saturated fat like butter which carries cholesterol and contains very little linoleic acid. Margarine was invented in France about a hundred years ago, when Napoleon the Third offered a prize for a butter-substitute. Basically it is a hydrogenated fat emulsified with about 15 per cent water. Today's products are in many ways an improvement on butter: they are intriguingly flavoured; they contain high proportions of linoleic acid and of other added nutrients like vitamins; they are so made as to remain soft and spreadable even when just taken out of the refrigerator; they are available for weight-watchers in low-calorie form (with about 40 per cent being simply water); and of course they are much cheaper than butter. Technology has thus given us a product that has far outstripped a natural food like butter. There appears to be room in India for margarines of such high quality, with their many advantages. By the present laws, colour and flavour cannot be added, so Indian margarine is hardly an appealing product.

Bakery fats

Bakery fats are hydrogenated fats specially designed for use in making cakes, biscuits and bread. Creation of fine solid crystals imparts a creamy consistency, and by whipping, a large volume of air or nitrogen is incorporated into the product. Both features play an important role in ensuring lightness in baked products (Chapter 8).

Monoglycerides

When glycerol has a fatty acid attached to just one of its three prongs, what results is a monoglyceride, and such products are made by reacting fats with an excess of glycerol. Monoglycerides like glycerol monostearate or GMS are powerful emulsifying agents, widely used in making baked foods, ice cream and the like.

CHAPTER 3

The Milky Way

Milk and its Products

The milk revolution

Thirty years ago, the daily milk came from a cow or buffalo milked at the gate. In cities and large towns this has now been all but replaced with milk retailed in bottles, plastic sachets, or vending machines. Behind this everyday occurrence lies a vast technological development that is revolutionising the entire traditional system that prevailed for centuries. Even though just about one-tenth of all the milk produced in India now passes through the modern system, this proportion is fast rising as the system expands. Let us take a look at this technological revolution.

The milk comes from village families, who own one or two cows or buffaloes. These are milked at home and the women carry this milk to the collection centres. A small quantity is drawn and tested, and paid for strictly according to quality the very same day. So the farmer has ready cash with which to feed his animal properly so that it gives more milk. The collected bulked milk is taken by truck to the chilling centre where it is quickly cooled to prevent bacteria present in it from multiplying. Sometimes milk may be sent directly to the dairy itself, if it is close enough.

At the dairy there is a continuous and busy sequence. The chilled milk from many centres is first warmed slightly to make it thinner, and then either filtered or twirled around in a centrifuge, both of which serve to remove any unsightly foreign matter that may be present. The milk has next to be cooled to 5°C or even lower, and this is achieved as it flows continuously through very thin, flat metal tins immersed in very cold water or brine. After chilling, the milk is held in storage, analysed, and then standardised

by addition of either cream or skim milk to ensure that the housewife will get a milk of identical composition every day.

Pasteurisation, an important step, comes next. It is named after the great French scientist, Louis Pasteur who showed, a little over a century ago, that heat could kill living microorganisms and thus prevent food spoilage. For the same reason, it is common in Indian homes to boil fresh milk as soon as it comes into the house. In a factory, the lower the pasteurisation temperature, the longer is the time needed to achieve sterility. Milk pasteurisation can be done at 63°C for 30 minutes, or at 72°C for 15 seconds (called high temperature-short time pasteurisation), or at 150°C for about half a second (called ultra high temperature pasteurisation or uperisation). Both bacteria that are not really harmful (but can cause the milk to spoil) and those that are, called pathogenic bacteria, are destroyed by pasteurisation. But if the bacteria had already multiplied to form what are called spores, these will survive pasteurisation, and in time will once again release bacteria into the milk. Once pasteurised when fresh, and quickly chilled to 5°C or lower, milk not only becomes safer but is conferred a long lease of life, which means that it can be transported (of course in chilled condition) in railcars or road tankers to cities even 300 kilometers away for distribution. To make doubly sure, it is again pasteurised after reaching the city before distribution to customers.

Distribution is effected in three ways. One is in returnable glass bottles capped with metal foil, and the other is in thick plastic sachets that need not be returned. The third is through a vending machine, from which chilled milk is drawn in definite quantities into the customer's own vessel using a special metal token purchased each time from an attendant. The bottle system has led to long, standing lines for collection. Plastic packages do avoid this, but generate vast numbers of empty sachets as waste. The vending machine does neither, but needs to be frequently filled with milk, kept chilled and attended to.

Thus overall the farmer-producer of milk receives a fair and steady cash price for his milk, and the consumer a convenient supply of wholesome milk of standard quality.

Generating and distributing milk

Gigantic organisational changes support this simple fact of milk reaching each of us. Never before in history has milk been collected

from millions of individuals and each paid ready cash the same day on the basis of quality, thus keeping them out of the money lenders' clutches. Cooperatives of such milk-producing farmers have also enabled gradual build-up of other facilities needed for dairying. Low-yielding local cows artificially crossed with semen from high-yielding foreign animals have yielded progeny with many times the milk output, and artificial insemination centres called bull-mother farms have been instituted to speed up the process. The quality feed and veterinary care that these crossbreds need have been furnished by animal feed plants and health care units established by the cooperatives.

On the technological front, the concept is one of milk chilling centres to cool rural milk soon after its collection, feeder dairies for pasteurisation, and refrigerated transport by road or rail to mother dairies established in the four metro cities, where the milk is repasteurised and distributed to city dwellers. Through the Operation Flood Projects, gifts of milk fat and skim milk powder are received by India under the World Food Programme. Techniques have been developed and facilities built up to blend these in suitable proportions with sterile water to give reconstituted milk of the right composition, which is blended with other milk. The money obtained from such sales has been used for building up the milk infrastructure. In a few years it is expected that enough milk will be produced in India to meet all the demands of the country. Since milk is an expensive food, there is a limit set by income to what can be sold. Even foodgrains like rice and wheat are in surplus not because everyone is eating enough, but because everyone does not have sufficient buying power.

Kinds of milk

In the past, we thought in terms of cow milk and buffalo milk. Cow milk was favoured in southern India, had about 4.5 per cent fat and gave a yellow butter and ghee. Buffalo milk was richer in fat (7 to 8 per cent) and in other solids, and gave more butter and ghee, though these were white in colour. The recombined or toned milk which now reaches us in bottles and sachets is a technologically standardised product with 3.0 per cent fat and 8.5 per cent of other solids, though there is also legal provision for a standard milk with 4.5 per cent fat and 8.5 per cent other solids. All these will yield less cream and ghee than will genuine cow or buffalo milk,

but for use in tea and coffee and for making curds such milk is adequate, and it does mean that available milk supplies can be stretched to cover many more people.

Some milk that is distributed is homogenised, which means that the fat is broken up into extremely tiny particles by forcing the milk through very fine orifices. Such milk, if kept in a refrigerator, will not form a thick cream layer on top, because the fat particles do not easily coalesce together. For this reason, homogenised milk is convenient to transport and distribute but by the same token, such milk will not easily yield cream at home, or even butter when the dahi made from it is churned. However it does disperse quickly in a tea or coffee decoction. Also, homogenised milk is conveniently diluted for use as a baby feed, and is easily digested in the child's stomach.

Powdered products

Milk powders: Removing from milk the 85 per cent of water that it contains gives whole milk powder. Thus bulk is enormously reduced, with the added convenience of a handy product that is far less perishable than liquid milk. If the fat has first been removed using a cream separator, one gets a skim milk powder which has no fat in it and therefore goes rancid far less easily than whole milk powder. Actually, whole milk powder has about 25 per cent fat and skim milk powder about 1.5 per cent; the protein contents are 27 and 36 per cent respectively, and in both products about 5 per cent water still remains.

Water removal is effected in one of two ways. One is drum drying in which thin layers of milk flow on the smooth surface of a cylinder, heated from the inside using steam, which keeps revolving inside an enclosed space in which a vacuum is created. The milk dries on the hot drum surface as a continuous sheet which is scraped off in ribbons using a sharp fixed blade, and then ground up. In spray drying, milk is sprayed through nozzles as a very fine mist at the top of a cylindrical chamber into which very hot air at 160°C is forced as a downward spiral which agitates the product violently. Milk powder falling softly to the floor of the drier is mechanically swept up, while some very fine particles which do not settle easily are recovered from the exhaust air which is continuously pushed out of the system. Whole milk powder, which has a lot of fat in it, needs careful packaging in a sealed tin under

a blanket of nitrogen which suppresses its turning rancid· once opened, it must be used up quickly. Skim milk powder is usually packed in a composite bag consisting of plastic polyethylene film, aluminium foil and paper all bonded or laminated together to prevent the ingress of moisture and air, the bag itself being then placed for support in a cardboard carton. Dry cool storage will help to preserve milk powders.

Drum-dried milk powders have a slight but distinct cooked or caramelised flavour and an off-white colour. They are coarser in texture and do not disperse in water as readily as does a spray-dried product, in which the protein is less heat-destabilised, or denatured to use the technical term. The lactose (milk sugar) present in dried milk is very hygroscopic, and in humid weather an open packet or tin will tend to cake, adding to the difficulty of dispersing it in water. Mixing milk powder with granulated sugar before adding to hot water helps its dispersion. Never should water be added to milk powder: it will cake into awkward lumps.

Baby food: When using animal milk to feed babies, it is usual to dilute with water to bring the fat and protein content down to the rather low levels in which they are present in human breast milk. For the same reason, extra sugar is added. In making commercial baby food from buffalo milk, the fat level is first reduced from 7 or 8 per cent to just 2.5 per cent. Next comes the addition of a phosphate buffer salt; this reacts with the calcium present to reduce the curd tension of milk, which is necessary not only to effect drying without curdling, but also later to form a soft, easily-digested curd in the stomach of the infant. Sugar is now added to reduce the eventual protein content to 22 per cent and the fat content to about 18 per cent. A certain quantity of iron needed by the baby is also incorporated. The product is sterilised by heating to 80°C and is then concentrated to remove a large quantity of the water. This is followed by a homogenisation process in which the product is forced under high pressure through very fine nozzles so that the fat is broken up into tiny particles which make product-dispersal easier. This homogenised concentrate is then reduced to powder either by drum drying but more usually by spray drying, after which the quantities of vitamins and minerals that a baby needs are mixed in. Packing in sterilised cans is done under nitrogen gas to displace all the air, and the lids are sealed on.

Specifications for baby foods, and indeed for many food products, are laid down by the Indian Standards Institution (ISI) through its many panels made up of scientists, manufacturers and representatives of government bodies, who together work out a consensus. Implementation of food laws in the country comes under the Prevention of Food Adulteration (PFA) Act and Rules which has an elaborate system of food inspectors to draw food samples, public analysts to test them, and Central Food Laboratories to act as referral centres; prosecutions are launched against those whose products are found to transgress the laws. Both ISI and the PFA authorities work closely together in drawing up food specifications.

Weaning foods: An older child, 6 months or more, is ready for soft solid foods as an addition to milk. Such weaning foods usually contain both cereals and milk, though they can be made even without milk. The ingredients are blended and cooked, and the slurries dried on heated rolls, flaked and packaged. Such precooked weaning foods are eaten as gruels with water or milk.

Malted milk powder: Just a century ago, in 1883, William Horlick in America invented a process for making a malted milk food, a product in which whole or skimmed milk or their powders are mixed with malt extract and cereal grain flour in such a way that all the starchy material is fully hydrolysed. Proteins are also partly broken down. No extra sugar, fat, colour or preservatives are permitted, except for cocoa powder. The product has, as percentages: fat 7.5, protein 14 and sugars 72: the protein and fat are in a partly-digested form helpful for use by children, convalescents and old people, and the malted flavour is an appealing one.

Barley is sprouted as for making beer (see Chapter 12), and the mash is extracted and dried. Usually such dry malt is simply purchased by the factory making malted milk foods, crushed, and steeped in warm water to solubilise the enzymes. Wheat flour is cooked separately in water to a paste and the two are mixed together at moderate temperature for about an hour to complete the breakdown of starch to maltose and dextrin, and of wheat proteins to smaller units. The solids are allowed to settle, and the liquid run off into a vessel, followed by two further water-extractions of the solids. To the liquid thus obtained is added whole milk, and the mixture is first concentrated and then dried either on a drum or as a spray, or more usually in a thin layer in trays in

an oven. The dried product is broken up and further ground coarse or fine, after which the malted milk food is packed in tins, usually with an inner metal seal to prevent tampering. Even after opening, the product will keep fresh for very long periods, perhaps because the fat particles (which are the main cause of rancidity in most food products) are each coated with a film of proteins, sugars and salts that keeps the fat away from oxidation by air.

Malted milk food can be made at home. First sprout either soaked barley, wheat, ragi or jowar till the roots emerge, rub off the skins carefully and dry in the shade. Then gently roast the sprouted material till a pleasant odour emerges, cool, and grind to a fine powder. Mix one kg of this thoroughly with 250g of milk powder, 25g of powdered sugar, 5g each of sodium bicarbonate (baking soda) and potassium bicarbonate (the mixture is sold as papad kar), a heaped teaspoon of fine table salt and a pinch of vanilla. Adding optionally 3 tablespoons of cocoa powder and a teaspoon of chocolate flavour will give a brown, flavoured product.

Ice cream and its mix: Ice cream powder is a new packaged product whose popularity, like that of ice-cream itself, is rapidly rising. First let us look at the ingredients in whole ice cream, and the principles used in making it. Milk fat, forming 10 to 12 per cent, is what gives ice cream its eventual body and creamy flavour. Skim milk powder, used in a similar quantity, is itself a mix of proteins, milk sugar (lactose), and mineral constituents like calcium, phosphorus, sodium, potassium, magnesium and so on; the milk proteins confer compactness and smoothness on ice cream, and the lactose some sweetness. However, extra sugar, about 14 per cent, is usually added for both taste and body. Another important constituent is the stabiliser, usually gelatin or carboxymethyl cellulose (CMC); these swell by absorbing enormous quantities of water, suppressing the formation of large crystals in the ice cream and thus ensuring smoothness and firmness in the frozen product. Emulsifiers conduce to the dispersion of the fat, and thus to foam stability when the product is being whipped up; the usual material employed is fatty acid monoglycerides (like glycerol monostearate or GMS) which, as we saw in Chapter 2, are derived from vegetable oils. Emulsifiers also produce smaller ice crystals and smaller air cells, both amenable to better distribution in the mix. Flavours

popular in ice cream are vanilla, strawberry, cocoa, coffee, pista and so on.

To make ice cream on a large scale, all the liquid ingredients are taken in a pasteurising vat, warmed and mixed, and the dry ingredients, well blended with the sugar, are added slowly with stirring to prevent lumping. Next comes pasteurisation to destroy disease-producing bacteria, either as a low temperature-long term (69°C for 30 mins) operation or a high temperature-short term (80°C for 25 seconds) one. Homogenisation follows next, and is designed, as in milk, to create a very fine suspension of fat which will not clump together, by forcing the warm fluid mix through very fine orifices under pressure. As the product emerges, it is instantly cooled to about 5°C for 3 or 4 hours, an ageing process which has been found to improve texture and body. Thereafter any colour and flavour are incorporated. Next comes the most important operation of freezing the mix rapidly (to yield small crystals) while also beating in plenty of air to give lightness. It seems incredible that in large continuous freezers, freezing-and-beating takes just 24 seconds at −5°C as the mix is pushed through by means of a pump, gets frozen, and goes out again. In batch freezers, the operation is slower, taking 6 to 10 minutes, and is effected in lots in vessels chilled with a refrigerant. These carry rotating scraper blades that wipe off frozen material from the walls, and beaters which introduce air into the product. Bulk-packed ice cream slabs will be almost double the volume of the starting mix, and this increase of 100 per cent is called the overrun. For softy ice cream, which is designed to be plastic and not stiff when taken from the freezing chamber, the overrun is kept at only 30 to 50 per cent, while it also contains much less fat (3 to 6 per cent) than does brick ice cream (10 per cent). Brick ice cream which leaves the freezer is kept in very cold rooms overnight to set and harden before packing in wax- or plastic-coated cardboard cartons, plastic tubs, waxed paper or foil. Softy ice cream is not hardened, but goes straight from the freezer into the retail dispensing unit.

Interesting changes occur in the freezer. The temperature drops rapidly, while the viscosity falls as the mixing breaks up the fat globules and pulls in air. Next ice crystals, which are pure water, are formed, thus concentrating the sugar in the remaining water so much that the latter will not freeze. Even after extensive freezing, some sugary water will still remain in frozen ice cream.

Today dry ice cream powders are available. The mix is preheated to 71°C, homogenised, sterilised and then spray-dried to give rather coarse particles, which are further sifted and packed. In some products all the sugar needed is added, in others the user can mix in fine-ground sugar to taste. Shelf-life is usually about four months.

Cream and condensed milk

Cream: When milk is left undisturbed in the cold, the fat globules clump together, rise to the top and form a thick layer of cream, which the housewife collects. Industrially, this coalescence of the fat in milk is effected in a cream separator, which employs the principle that a powerful centrifugal or spinning force will pull the lighter fat away from the heavier skim milk in which it is floating. The machine can be turned at home by hand or industrially by electricity, and by adjusting it, cream varying from 20 to 60 per cent fat content can be obtained. This is sterilised, homogenised, cooled and canned, and the whole tin sterilised once again. Cream in a tin can be sweet or plain, and the fat content is usually 20 per cent.

Condensed milk: The name really describes the product correctly, since it is milk that is boiled down or condensed in a pan under vacuum to bring the water level down from 80 per cent to about 25 to 30 per cent. The other constituents present are concentrated correspondingly: fat and protein to about 9 per cent each and lactose (milk sugar) to 11 per cent. Usually extra sugar is added to give a final concentration of 40 per cent but unsweetened condensed milk is also made. Condensed skim milks, both sweet and plain are also known, with just 0.5 per cent fat. Other intermediate steps after the concentration are homogenisation to give a smooth product, packaging, and can-sterilisation. The light brown colour and characteristic taste of condensed milk result from slight caramelisation of both the natural and added sugars. Added sugar enhances preservation, and final sterilisation, though always carried out, is even unnecessary.

Butter and ghee

Butter: In the home, milk is customarily seeded overnight to curd, and the curd diluted and churned to give buttermilk (chaas or moru) and butter. The latter may be eaten (for example as an

accompaniment to makai roti or masala dosa), or boiled down to give ghee. Sometimes cream, skimmed off daily from boiled-and-cooled milk, is pooled together for a few days, and then churned (sometimes simply by shaking in a bottle) to give butter.

Commercial butter follows the cream route. The 30 to 40 per cent cream separated in a cream separator is first aged overnight at 5 to 10°C, and then ripened or fermented for 15 to 16 hours after adding two kinds of pure cultures: bacilli like *Streptococcus lactis* and *Streptococcus cremoris* to convert the lactose in milk to lactic acid, and organisms like *Streptococcus diacetilis*, *Leuconostoc citrovorum* and *Leuconostoc dextranicum* to produce the delightful aromatic flavours of butter. Chief among these is diacetyl, even one gram of which in a thousand kg of butter, or one part in a million, gives butter a rich flavour. Lesser flavour components are acetic and propionic acids. The ripened cream is next rotated at about 10°C in a butter churn, essentially a device to agitate the cream, and cause concussion and coalescence of the separate globules of fat into large, pea-sized clusters of butter which separate out from the watery portion. During churning some yellow butter colour is added to enhance the appeal of the butter. One is a dye called annatto obtained from certain seeds, and the other is carotene, the orange-yellow colour present in carrots and mangoes. After the watery layer is drained away, the butter is given a wash by gently churning with fresh cold water. Next the butter is continuously kneaded or worked with several objectives: to expel water in excess of the prescribed 16 per cent legal limit, to distribute the 2 per cent salt which is incorporated to improve both taste and keeping quality, to fuse the butter globules into a smooth body, and to introduce air uniformly throughout the mass (about 40cc is present in a kg of butter). The butter is now automatically wrapped in parchment or butter paper, each slab placed in an outside cardboard carton, and the boxes kept in a cold room.

Ghee: In commercial ghee-making, unsalted butter derived from ripened cream is heated in a stirred vessel fitted with a jacket till it melts, after which the temperature is raised to boil off water. This is accompanied by effervescence and a crackling sound; the temperature does not rise till all the water has gone, when it suddenly shoots up and must be carefully controlled if the ghee is not to be burnt and is to acquire the delightful aroma for which it is prized. The hot ghee is strained away from the

brown residue, packed in bottles or tins, and thereafter put in cold storage. Rapid chilling will first engender small seed crystals, and subsequent slow cooling will cause them to grow into the large granules in a liquid base which has consumer appeal.

Ghee made by the traditional dahi route and boiled down with care has a rich flavour derived from constituents that are formed both during the fermentation of milk to dahi, and later when butter is melted down. Little is known about the products that give ghee its aroma, but like most food flavours they are an extremely complex mixture. What is known in practice is that the watery component of butter contributes to aroma during boiling down: if butter is melted, allowed to stand, the lower serum layer removed and then the fat boiled down to ghee, the aroma is distinctly poor, as is likewise the colour. Also, the ghee made by heating butter that has been derived from unripened cream has a rather flat flavour. Even worse is ghee made by simply boiling down fresh unripened cream: this can be done, though it is a slow process since there is much more water, about 65 per cent, present in cream than the 16 per cent in butter. Addition of some citric acid, dahi, buttermilk or skim milk powder to such materials during boiling down is said to improve both flavour and colour.

Dahi, yoghurt and shrikhand

Dahi-making in the home by seeding boiled milk cooled to body temperature with 2.5 per cent (one tablespoon to a litre) of good curd from the previous batch, followed by undisturbed fermentation and setting in a warm place overnight, is familiar to every Indian housewife. However, one cannot still buy a tub of dahi from the market, though other products needing refrigeration like butter and ice cream are fairly widely available.

In advanced countries, commercial yoghurt has in the last two decades become an immensely popular food. In place of the mixed organisms present in dahi, an equal amount of two pure cultures, *Streptococcus thermophilus* and *Lactobacillus bulgaricus*, is added to whole or partly-defatted, homogenised milk at 43 to 44°C, stirred gently, and filled into plastic or waxed cardboard tubs. These are then held for fermentation at 41 to 42°C for 3 hours, followed by cooling for 8 hours at 5 to 7°C. Flavours, colour, sugar and fruits may be added to the milk before its incubation or to each package, and help to mitigate and modify the

acid taste and flavour of plain yoghurt and widen its appeal, especially for children.

Cultured buttermilk is made similarly from skim milk. Acidophilus milk, for which many health claims are made, derives from the incubation of either whole, skim or partly-skimmed milk with a pure strain of *Lactobacillus acidophilus* at exactly 38 to 39°C, followed by gently breaking up the soft solid mass, adding lactose or dextrin, and stirring to a smooth consistency. Great care is necessary, since given the chance other bacteria will rapidly outgrow the acidophilus organism. Neither product is available in India.

Shrikhand is being produced commercially on a test-marketing scale in Baroda. Dahi made from pasteurised skim milk is pressed free of most of its liquid, and into the white curd is folded sugar and powdered cardamom seeds. The product is held under refrigeration till its sale in plastic tubs.

Cheeses

Indian cheese: Ripened cheese is not a common traditional product in the sub-continent. Only in a few pockets in the hilly areas of the northern and north-eastern hills are Bandal, Surati, Dacca and Kalimpong cheese made.

Commercially only a processed cheese is manufactured in India. First a choice is made of raw cheese stocks from various batches that differ in age, and hence in acidity, flavour, body and gassiness: thus 3 parts of a mild, smooth and firm product which is zero to 3 months' old may be blended in a grinder with 1 part of a 6 to 12-month old cheese which is strong in flavour, grainy and crumbly. Into this hot melted mix is further blended water, colour, salt, a preservative and an emulsifier, consisting of a mixture of disodium phosphate and trisodium citrate, to give a smooth, plastic, flowing product which is packed in tins or as small blocks in aluminium foil. Processed cheese contains about 47 per cent water and 21 per cent fat. It can keep for fairly long even after the tin or packet is opened, but tends to dry out and lose its smooth and spreadable texture.

World cheeses: Some of the more famous among the 400 world cheeses are worth brief mention. Fresh cheeses include cottage cheese, which is just skim milk curd that is drained, granulated or cubed, heated to firmness and coated with cream. Fresh cream

cheeses are made either from milk enriched with cream, or cream itself, and pressed and moulded to smoothness; an example is the Italian mozarella, kept moist in its own buttermilk. Ricotta, also from Italy, is an unusual cheese derived by heat and acid-precipitation of whey. The next category embraces the soft-ripened cheeses, which ripen from the outside to the centre because the bacterial culture is sprinkled or sprayed on the surface; this also results in a soft crust. Camembert, the thin red-brown or green-stained French cheese is one example, and so is the large, round, thin, red-splotched Brie from the same country. Semi-soft cheeses are of two kinds. One kind is periodically washed with salt water, whey, wine, beer or cider, so that the rind remains supple while fermentation proceeds inside; the Munster and Bel Paese, both mild in flavour and butter-smooth in texture, are examples. The other kind comprise the many semi-soft cheeses with their network of blue-green veins caused by penicillin mould radiating in cracks within. Stilton from England is a fat-enriched variety in which the cracks are caused by natural drainage, while Roquefort is a French sheep milk cheese with an over-powering "goaty" flavour, which is ripened in the cool, damp natural caves in which the region abounds. Gorgonzola, the famous Italian cheese with its sharp "bite" on the tongue, is stabbed during ripening so as to assist penicillium mould penetration. A slightly harder cheese is Limburger from Belgium, made in the form of small blocks; *Bacillus linens* organisms are smeared on the curd surface and yield a cheese with a brownish-red coat and a penetrating "sweaty" odour. In the semi-hard cheese category fall a number of famous varieties. Emmental and Gruyere, both from Switzerland, are characterised by a golden rind and holes or "eyes" in the body, caused by introduction of organisms like *Streptococcus thermophilus, Lactobacillus helveticus* and propionic bacteria. Cylindrical Gouda cheese from the Netherlands is a mild yellow product, and Edam, also Dutch, is similar but characterised by its round shape and red-dyed wax coating. In a special class are the 40 or so French cheeses made from goat's milk, with their special flavours and white or bluish rind. Finally, there are the aged, hard, granular ripened cheeses with their rich flavour. In this category fall the cream-coloured English Cheddar with its firm body, and the strong-tasting Italian Parmesan which is usually grated over

spaghetti, pizza and pies, and is reputed to last even over a man's lifetime without going bad.

While these cheeses were once made locally in ways that developed with centuries of practice, standard industrial procedures have now been developed for many major cheese varieties that have a wide appeal. Thus the USA now makes far more "English" Cheddar cheese than does Britain, France more Gruyere than Switzerland, and Germany more Emmental than its country of origin, also Switzerland.

Khoa-based sweets

Khoa or mawa is evaporated milk, prepared by heating it to a doughy consistency in an open kadai (pan), with constant stirring and scraping with a metal khunti. A dry khoa product called pindi, with 32 per cent water, is used to make sweetmeats like burfi and peda. A less-dried material, dhap, with 37 to 47 per cent water, is fashioned into gulab jamun and pantua, while a grainy variety called danedar made from old and highly acid milk is favoured for preparing kalakand, gourd burfi and so on. Buffalo milk with its higher fat content of 7 to 8 per cent yields a softer and smoother khoa than does cow milk with 4 to 5 per cent fat.

A continuous technology for making khoa has been devised. The essential units are a steam-heated drum fitted with a scraper in which the milk is first concentrated, and open pans for khoa preparation, also heated with steam, in which suitable mechanical scrapers collect and knead the khoa and push it out when finished.

For making gulab jamun, a ready mix is available commercially. This consists of desiccated khoa, skim milk powder and maida, some citric acid to furnish acidity and a little sodium bicarbonate to act as a leavening agent when the mixture is moistened. The mix must be wetted, fashioned into balls, and deep-fried to a golden brown colour, a change which involves browning and caramelisation reactions. Thereafter the balls are immersed in a flavoured thin sugar syrup.

Pantua is a product, crescent-shaped and lighter in colour than gulab jamun, but like it soaked in sugar syrup.

Channa-based sweets

Channa, or paneer as it is also termed, is made on a mechanical basis for further conversion to sweetmeats like rasogolla and

sandesh. Fresh cow's milk is heated to a high temperature of 80°C, slow stirred, and rapidly coagulated by adding to it a 1 to 2 per cent solution of lactic or citric acids, or even natural sour whey from a previous operation. Lactic acid gives a granular channa well-suited to rasogolla making, whereas citric acid yields a plastic product excellent for sandesh. The whey is drained out while hot, and the product suspended in cloth bags in a bath of cold water to leach out adhering whey. Thereafter it is run through a kneading machine to give it smoothness.

Rasogolla balls are made by gently shaping the channa, followed by immersion in flavoured sugar syrup, canning and sterilisation. Flat discs of channa immersed in sweetened concentrated milk constitute rasmallai.

Sandesh, a dry, faintly gritty product, is believed to get its name through being offered to guests who brought sandesh or good news. Channa, sugar and flavouring are blended under low heat by beating with wooden spatulas, followed by shaping in teakwood moulds. A special flavour and light brown colour are imparted when palm jaggery is the sweetening agent.

New milk-derived products

Miltone is a blend of milk with a slurry of protein isolated from groundnuts. The latter is made from a high-quality groundnut oilcake (left after the oil has been pressed out from the nuts) by dispersing it in alkaline water, filtering away the insolubles, and using the remaining liquid to make a dispersion of pure protein in water. This is blended with glucose, vitamins, minerals, flavours and an equal quantity of whole milk to give a product which resembles milk in looks, taste and nutritive quality. Essentially it is a method of toning milk not with milk powder but with vegetable protein. The product is available commercially in flavoured form as a drink in Bombay, but its volume usage is in the supplementary children's feeding programmes which operate in several states in India.

Chai sathi is a product made by blending skim milk with vegetable fat, milk and vegetable proteins, emulsifiers, stabilisers and vitamin A, followed by homogenisation. It has many qualities demanded in an Indian home: a milky taste, ability to whiten tea

and coffee, and capacity to set to curds, besides being less expensive than milk.

Nutritive value of milk and its products

As Table 3.1 shows, cow milk is 87.5 per cent water, but the 12.5 per cent of solids consist of an almost equal blend of the three macro elements of nutrition, fat, protein and sugar, the last being milk sugar or lactose. Since milk is a food designed for a young animal, all these constituents are exceptionally suitable for children. The mineral constituents make up less than one per cent, but this includes two important items, calcium and phosphorus, in good quantity. The fat in milk carries dissolved vitamin A at a fair level, and in the watery portion are three important B-vitamins, namely thiamine, riboflavin (at a high level in relation to nutritional needs) and niacin. Milk is a poor source of two rather important micronutrients: iron, a mineral, and vitamin C, so both are omitted from the table. Pasteurising, boiling and even concentration by condensing or spray-drying, cause very little nutrient destruction.

In skim milk, all the fat is gone, and with it all the vitamin A. About one-third of the protein in the original milk has been carried away with the cream, leaving in the skim a reduced quantity, but all the sugar, minerals and B-vitamins are there in skim milk.

What about milk powders in which the water has been taken away? Whole milk powder represents a 6 to 7-fold concentration of both major and minor nutrients. In skim milk powder, this concentration of the original constituents is 10 to 12-fold. Adding these powders to any food prepared at home will boost the nutritional quality of the preparation.

Condensed milk is partly concentrated whole milk, with a 2.5-fold upstaging of all constituents, major and minor. Sweetened condensed milk, to which 40 per cent sugar is added during manufacture, will end up with over 50 per cent of total sugars. Whole milk dahi, as Table 3.1 shows, is very similar to milk in composition, except that about one-third of the lactose has gone, having been converted to the lactic acid which gives dahi its sour taste. Living bacteria are present in large amounts in dahi; when eaten, these are believed to have several beneficial effects on food digestion by

TABLE 3.1

Nutritive value of Milk and its Products

	Calories	*Major nutrients*				*Minerals*			*Vitamins*			
		Water %	*Fat %*	*Protein %*	*Sugar %*	*Total mg*	*Calcium mg*	*Phos-phorus mg*	*Vit. A mcg*	*Thia-mine mcg*	*Ribo-flavin mcg*	*Niacin mcg*
	All figures in 100g of product											
Milk												
Whole milk (cow)	67	87.5	4.1	3·2	4.4	800	120	90	55	50	190	100
Skim milk	29	92.1	0.1	2.5	4.6	700	120	90	Nil	40	170	100
Milk powders												
Whole milk	496	3.5	26.7	25.8	38.0	6000	950	730	420	310	1360	700
Skim milk	357	4.0	0.1	38.0	51.0	6800	1370	1000	Nil	450	1640	1000
Whole milk products												
Condensed milk	170	26.0	9.0	8.3	11.0	1700	260	200	100	120	390	200
Dahi	60	89.1	4.0	3.1	3.0	850	150	95	30	50	160	100
Fat-rich products												
Cream	250	68.2	25.0	2.5	3.7	700	100	80	330	30	120	40
Butter	730	16.0	81.0	Tr	Tr	250	50	40	960	3	15	50
Coagulated milk products												
Channa (paneer)	265	57.1	20.8	18.3	1.2	1600	210	140	100	70	260	240
Cheese (processed)	335	45.0	25.0	24.0	3.8	5000	800	520	85	40	350	80

T = Trace

the microflora in the large intestine. Shrikhand will represent dahi concentrated by draining from a 90 to a 60 per cent water level.

Cream and butter are fat-rich products. Butter is nutritionally simply the fat of milk (carrying all the original vitamin A); since butter is washed during manufacture, the 16 per cent watery portion has only traces of nutrients, other than added salt. Cream is made up of two-thirds its weight of milk serum, so apart from 25 per cent fat (with its vitamin A) there is some protein and milk sugar, about the same proportion as in milk, besides two-thirds the original B-vitamin levels.

When milk is coagulated by adding acid, the precipitate carries almost all the fat and all the casein protein, and about half the minerals and half the vitamin A, and as Table 3.1 shows, the composition of channa or paneer reflects this distribution. The watery whey that is left over will carry all the lactose and lactoglobulin protein, and the other half of the minerals and vitamin A. Processed cheese is even more concentrated, with 25 per cent of fat and protein, just a little sugar, and high levels of calcium and phosphorus since these are added. Cheese is a calorie-rich food, with fair levels also of vitamin A and the three B-vitamins. However, the biogenic amines, tyramine, histamine and phenylethylamine, that arise in certain cheeses and in foods like chocolates and red wines, have been blamed for dietary migraines.

CHAPTER 4

Tastes That Differ

Sweet and Salt

SUGAR AND JAGGERY

INDIA RANKS AMONG the countries that make the most white sugar, producing about 6 to 7 million tonnes a year. Alongside it are the USSR with 9 million tonnes, Cuba with 7 and Brazil with 7, and following these is the USA with 4 million tonnes. Historically India can claim a first: a reference to the preparation of jaggery as long ago as the sixth century B.C. And Megasthenes, the Greek governor who was in India in the 7th century, has recorded in his writings a mission sent by the Chinese emperor Tai-Toung to Magadha, the modern Patna, to learn how sugar was made.

Kinds of sugar

Traditionally we have made either crude brown sugar, called jaggery or gur, or khandsari which is lumpy rock sugar. Fine crystal sugar has been manufactured only since the turn of the century. Today some 250 factories, located largely in U.P., Maharashtra, Bihar, Andhra Pradesh and Tamil Nadu, manufacture the 6 to 7 million tonnes of crystal sugar that we produce annually. About twice this quantity of jaggery is still produced, but khandsari production is now just a tenth that of sugar. Jaggery is made not only from sugarcane juice but also from the sweet sap of the toddy palm and the date palm, but khandsari and sugar in India derive entirely from the sugarcane. In temperate countries, special varieties of sugar-rich beetroots have been developed as a source of sugar; a beginning is being made to grow them in India also since the growing season is short, the requirement for water is much less than for the sugarcane, and the yield of sugar per hectare is twice that from the cane.

Making crystal sugar

A tonne of sugar comes from 10 tonnes of sugarcane, which itself occupies 2 hectares (5 acres) of land. The plants are usually sown in January-March, and harvested 10 to 12 months later. The cane is cut down, taken to the factory, and shredded into small pieces, which are then crushed to squeeze out the juice in very heavy rollers (small roadside juice dispensers are a familiar sight). Another more recent technique is to leach out the juice using water, which eventually extracts more sugar than does crushing. The juice as expressed is greyish-green in colour, turbid, quite acidic and not terribly sweet.

Next this milky juice must be clarified. To do this lime is first added, and then either sulphur dioxide gas or carbon dioxide gas is passed in. When this treated juice is filtered, a muddy, shiny material is held back and a clear sugar solution passes on.

At this stage the solution is decolourised by treating it with granular carbons that have their surfaces specially activated to adsorb colouring matters from other liquids. Such activated carbons are also used to decolourise vegetable oils after refining with alkali (Chapter 2). After decolourisation the carbon is filtered away, and the sugary liquid is evaporated under vacuum in a stepwise fashion. In the last stage, the sugar solution is boiled down, again under vacuum, and thickened until sugar crystals begin to appear. Then these crystals are grown by adding more syrup and boiling down, periodically withdrawing samples and watching the crystal size. No new grains are allowed to form, and if this happens, fresh juice is drawn in to dissolve them. When the size required has been reached, the mass of sugar crystals along with the solution, which is called massecuite, is run into crystallisers and allowed to further crystallise slowly in the cold. After this, spinning or centrifugation in a perforated bowl throws the liquid molasses out, leaving the sugar crystals in the bowl, where they are washed free of adhering molasses by a quick spray of water. The first molasses from this operation is mixed with fresh sugar syrup, and a fresh crop of sugar is gathered by similar steps of thickening and crystal-growing. Three or even four crops may be taken before the molasses is discarded.

It may be a surprise to know that in trade terms there are five grades of sugar depending on crystal size, and that in each grade

two colour levels are permitted. Commonly the public are supposed to be sold only three rather large-sized sugars, all of superior colour grade, but lower grades doubtless worm their way into the market!

Other kinds of sugar

Cube sugar is made by shaping fine-grained sugar crystals mechanically into cubes. This is an expensive process, so cube sugar is costly. The cubes should be hard enough to stand packing and transport, but porous enough to disintegrate when added to a cup of tea. *Icing sugar* or *castor sugar* is made by grinding crystal sugar in a rotating pan carrying steel balls which powder it really fine, usually adding about 5 per cent of starch powder to prevent sticking and allow for a free flow; for the same reason, icing sugar is packed in sealed tins so that it will not pick up moisture. *Brown granulated sugar*, which has a characteristic flavour, is made by forced vacuum crystallisation of the final molasses, after special treatments to remove some of the iron present and reduce the dark brown colour. Such brown sugar is used to sweeten a cup of coffee at table. In India, frequently white sugar is simply given a surface colour by coating the granules with molasses or caramel sugar solution, which causes the crystals when disturbed to move or creep in a life-like way! Such coated products lack the distinctive flavour of crystallised brown sugar.

Liquid sugar is not as yet common in India. Sugar is of course just sucrose, which can be broken down by heating with an acid or treatment with an enzyme into its two constituents, glucose and fructose. This mixture is called invert sugar, and liquid sugar is an almost fully inverted product. It is as sweet as sugar itself, and being a liquid, it is easier to measure out and dissolve when making confectionery or soft drinks, or in baking or canning, than to add a solid like sugar. Sugar inversion will come up again, particularly in Chapter 10.

Glucose is of two kinds. Solid dextro-glucose (dextrose) is produced by hydrolysing starch (which is nothing but a string of glucose units) using an acid, after which the solution is concentrated, decolourised and crystallised. Solid glucose is used as an invalid food, an energy tablet and in various medicines. Liquid glucose is obtained similarly, but the starch is hydrolysed only

partially to give a glucose-maltose mixture in about 50 per cent concentration which is further evaporated till it contains about 15 per cent of water. It is used in making bread, biscuits and also taken by mouth in cases of dehydration of the body. Since starch is plentiful, and its hydrolysis is a simple matter, these liquid sweeteners are replacing sugar in many applications, and may in future take their place even in the kitchen and on the dining table.

Jaggery

Jaggery or gur being a traditional product is produced in ingenious ways perfected over time. It was usual to crush the cut cane in a kohlu, a wooden or stone mortar in which a pestle travels round and round on animal power, but later this arrangement was augmented with two heavy wooden or metal rollers mounted either horizontally or vertically. Today it is common to find metal three-roller corrugated crushers, vertical and animal-driven for small operations, and horizontal and electrically-driven where larger quantities are crushed. The juice is immediately filtered into a bel or pan, and boiled to stop its inversion into glucose-fructose by microorganisms, to coagulate certain impurities and to lighten its colour. Scum is ladled away and to the boiling juice are added certain traditional gummy extracts for purposes of clarification. These are made either from the stems of two plants of the hibiscus family : deoli and bhendi (ladies finger); or from the barks of three other trees : the phalsa (whose dark red berries give a refreshing acidic summer drink), the simul or red silk cotton, and the sukhlai or karaya, whose gummy exudate is the prized gum karaya used in foods, medicine and paper making. Scum rises to the top with each addition and this is cleared away. In fact experience has shown that heat should be applied to only one corner of the bel, so that the colder liquid will carry the scum by convection across to the opposite side. When the liquor has almost totally cleared, sajji (a crude blend of sodium carbonate, sodium sulphate and sodium chloride) is added in small quantities to complete the clarification. The first scums are greenish and are termed dhandri; the last white scum is called chandoi, and its appearance is an indication that the clarification process is over. The juice is now boiled vigorously to evaporate

water and thicken it almost to a semi-solid mass. Frothing is controlled by frequent sprinkling of a water-extract of castor seeds. The size and shape of the bubbles formed on the surface, and the sound produced by their bursting, tell an experienced operator when to stop. Constant stirring is now carried out so that charring does not occur, and when the mass leaves the sides of the pan without coating it, the contents are turned into a circular plate or chak, stirred with a hand-spade or khurpi and allowed to cool. When almost solid but still soft, the khurpi is used to scrape off the mass and fashion it either into balls called laddus, or into rectangular blocks, or into half-spheres called bhelis. These harden on standing overnight and are packed in gunnies or boxes.

Quality in jaggery is mainly a matter of light colour, sweet taste, granularity between the fingers (a crystalline form is preferred for eating and a sticky type for making sweets), and hardness, which reflects the amount of water present. Regional preferences are for even quite opposite qualities. If too much inversion has taken place the sucrose will not crystallise and the texture will be gummy; the sweetness will not suffer, since fructose is sweeter than sucrose and glucose less sweet. But refiners who buy jaggery for making khandsari or crystal sugar will get a lower yield if excessive inversion has occurred.

Apart from the sugarcane, jaggery is also made from the sweet sap of the palmyra or toddy palm, and the date palm especially in West Bengal and Tamilnadu. Coconut and sago palm saps are much less employed. The sap is drawn by making incisions on the stalk bearing the flowers, the spathe as it is called, in both male and female plants. In females juice is drawn both from the spathe as well as from young fruits. In the date palm juice is tapped from the trunk at the top. It is hard work shinning up 20-metre high trees twice or thrice a day, using one rope loop for the feet and another for the body, to fix and remove the clay pots, earlier either smeared with lime or smoked, into which the juice drips. The juice is boiled down in earthen pots (chattis or jhalas) or iron pans, using crushed castor seeds or copra chips to control frothing. In Bengal boiling down may be done stepwise in a series of jhalas; when the mass is nearly semi-solid, it is cooled with vigorous stirring, and some jaggery crystals are added as a seeding agent. In Tamilnadu

the mass is transferred to solidify into coconut half-shells or palmyra leaf baskets which act as moulds, and in West Bengal to a vessel called sharas. Palm jaggery or tad-gur has a pale brown colour and delicate coconut flavour that is relished. In Bengal palm jaggery is boiled down with milk which is then set to curds called mishti dohi, and a special sandesh is flavoured also with such jaggery.

Khandsari or lump sugar

The process for making khandsari or open pan sugar from sugarcane juice is exactly that for making jaggery, namely boiling, clarification and thickening, but in the last stage there is a difference. The juice is boiled down in open pans almost to the point of crystallisation (but before it will set on cooling), poured into earthen pots or nands to cool, and the cold, saturated solution transferred for crystallisation into small earthen or tin containers called khalsis for a 7 to 10-day period. The crystals along with liquid is called rab, and from this the solid khandsari lump sugar is removed leaving the first molasses. This may once again be boiled down to yield a second crop of khandsari sugar. The second molasses is too exhausted to give another crystallisable crop, but can be boiled down further to furnish jaggery of medium quality.

Sugars in nutrition

Sugar itself is exceptionally pure sucrose, 99.5 per cent. It is a carbohydrate, and gives 4 kilocalories (which in nutrition are simply termed calories) for each gram. The same value holds for starch, glucose, fructose and any other sugar-type product. In the stomach sucrose is rapidly split into its two constituents, glucose and fructose, so the exaggerated claims for glucose as a source of instant energy must be taken with a pinch of salt ! Though today the use of sugar or jaggery is so widespread, they are by no means an essential constituent of the diet: starch will do just as well simply for nutrition, but sugar does of course add taste to foodstuffs.

Even invert sugar, which is present in the jaggery made from cane juice to the extent of 15 to 20 per cent, is equivalent to sucrose as a source of calories. Such jaggery also carries several constituents which pure crystal sugar does not have: 10 to 12 per cent of water, about 0.5 per cent of protein and fat, 4 per cent of various

minerals like calcium, potash, soda and phosphates, and about one mg/100g of iron and copper picked up from the vessels used in its manufacture. Palm jaggery has some characteristics of its own. The sucrose level of 80 per cent is higher than the 60 to 70 per cent in cane jaggery, invert sugar constitutes just 2 per cent, protein and fat together make up 3 per cent, and iron contents can be as high as 10mg/100g. None of these differences from crystal sugar are particularly important in terms of nutrition, except perhaps the higher iron level if this is present not as inorganic iron (which is absorbed poorly), but in organic bound form.

Sugar has been blamed for many illnesses of modern society. Caries or the pitting of teeth is one of these. Normally teeth are covered with a film of saliva. When sugary food is put in the mouth, lactobacillus bacteria immediately start to convert it to acid, and a tiny amount of calcium from the teeth could be dissolved out. Normally fresh saliva will nullify this acid if the quantity of sugar is small, and if the teeth are really clean and free from bacteria. Certain other strains of bacteria in the mouth, streptococcus and actinomyces, convert sugar into a sticky substance called dextran which lodges on the teeth, where it can build up to form what is called tooth plaque, a dull dirty-white layer. Plaque itself breaks down to glucose which then forms acid: this can go on continuously when plaque is present, and not just when sugar is eaten. When the acid has bored a real hole in the teeth, pitting or dental caries has occurred. Rather than the quantity of sugar, it is its too-frequent consumption as sweets, sweet tea or coffee, or soft drinks, that disposes to caries. The remedy, therefore lies in avoiding sweets frequently, brushing teeth thoroughly with a soft toothbrush, and practising the good Indian habit of rinsing the mouth thoroughly after every meal.

In the diabetes that comes with age, sugar has to be avoided. This is not because the insulin needed to metabolise sugar in the body is deficient, but rather because more insulin seems to be needed to transfer glucose into the cells, so that insulin output actually goes up. There is no evidence that eating more sugar leads to diabetes, but once it comes on, sugar must be given up. Today drastic cutting down of cereals like rice and wheat in the food is not recommended: instead meals should be lighter and spread out more frequently and evenly over the day.

What about obesity? Sugar is not in itself a cause of overweight,

and any excess energy from food that is not used up, whatever its source (oil, for example) will be stored in the body mainly as fat. The difference is a human one: fat does not stimulate the taste buds, whereas a sweet snack may be irresistible !

Heart disease has most frequently been linked with the kind and quantity of cooking oil used in the kitchen. However, a connection with sugar consumption has also been forcibly advocated. It is pointed out that affluent societies, or groups of the population who are more at risk from coronary thrombosis, are characterised by several types of environmental stresses, but a high sugar consumption is always one of them. Several of the many clinical and laboratory abnormalities found in coronary thrombosis are also produced experimentally by diets rich in sugar. Again, women are much less susceptible to heart attacks than men, suggesting that a disturbed hormonal balance, which is tempered in women by the ovulation cycle, is responsible. The close link between diabetes and heart disease could suggest that the basic cause of both is the increased concentration of insulin in the blood which occurs after eating sugar; indeed other stress factors like cigarette smoking and physical inactivity have the same effect of releasing insulin.

Sugar/jaggery intakes in India are around 35 grams a day, with higher figures in Punjab (80g), and Gujarat (50g), and lower ones (20 to 10g) in Andhra Pradesh, Tamilnadu, Uttar Pradesh, West Bengal and Orissa. Even affluent groups in India seem to eat far less sugar than the national averages of advanced countries, which can exceed 150g daily.

Honey

Cave paintings that are 20,000 years old show men despoiling beehives and being stung for their efforts! Honey is not really processed by man. That credit should go to bees, who build factories to store the honey that they make in their bodies from flower nectar. When a bee has found a new source of nectar, it comes back to the hive, and as other bees watch, executes on it a kind of dance: the angle of the dance shows the direction of the honey source with reference to the sun, and the vibration of the abdomen indicates its distance from the hive. Every honey bee is a born surveyor, teacher and worker.

Today honey is an industrially-marketed food. Artificial hives

with movable inner frames are employed, and the honey when ready is removed by uncapping each cell with a knife followed by centrifugal swirling of the frame to draw out the honey without destroying the waxy cellular comb, which can be put back into the hive for use again. Excess water is removed by keeping the honey warm for an hour, but too much heat will destroy the enzyme activity. Indian honey consists of the following, expressed as percentages: water 20, sugar (sucrose) 3, glucose 11, fructose 39, other sugars, gums, wax and minerals 7. Besides, it has some B-vitamins and a little vitamin C. On standing, especially in cooler weather, sucrose and glucose begin to settle down as mushy crystals, which can be redissolved by warming. Microorganisms, including pathogens, do not grow on honey perhaps because of its high osmotic pressure.

There are many nutritional myths about honey, such as its contribution to fertility, youthfulness and longevity, which its composition belies. Mostly it contains sugars, and is therefore of no more nutritional value than ordinary table sugar. The content of vitamins is too small to have any worthwhile nutritional impact. As we have seen, sugar has a connection with caries or the pitting of teeth, and honey is no different. Glucose is absorbed into the body in the intestine, and only a very small quantity from the stomach, so even eating honey or glucose as a source of "quick energy" before any physical activity is of doubtful validity: sugar would do just as well. Honey has of course a lingering sweet taste and a delicious flavour, which are enjoyable in themselves without the need for other exaggerated claims on its behalf.

Other sweeteners

Diabetics especially are familiar with saccharin as a tablet or liquid that is sweet. A lot of saccharin also goes into soft drinks, a bottle of which will contain about 18mg. The sweetness of saccharin was discovered accidentally when a chemist named Fahlberg ate a piece of bread after handling the substance in his laboratory. Saccharin is made starting from toluene, a chemical present in petroleum, in a series of steps. Since saccharin itself is not very soluble in water, it is used in the form of its very soluble sodium salt. There has been some scare that use of saccharin gives rise to bladder cancer in animal experiments, but a 50-year history of even heavy use by diabetics all over the world appears to

suggest no danger from its consumption.

Another sweetening agent, sodium cyclamate, has also come under the cancer-generating cloud, but again there are doubts whether this is really so. It is made from aniline, another petrochemical, and while the compound itself is sweet-and-sour, both its sodium and calcium salts are intensely sweet.

A third sweet substance that has been cleared for use in the USA after exhaustive testing is called aspartame, a combination of two amino acids, aspartic acid and phenylalanine, in the form of a methyl ester. It is not yet in use in India.

A fruit called *Thaumatococcus danielli* found in West Africa carries a protein called thaumatin with a very sweet taste, which is now being tested. Many will recall that after chewing a sour amla (nellikai or gooseberry), a sip of water tastes very sweet. This concept may be relevant in finding further new sweeteners.

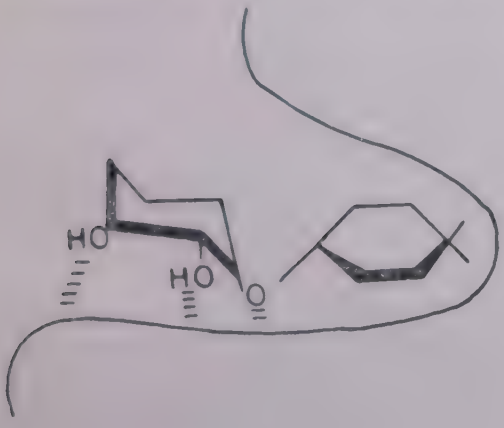
What causes sweetness ?

Taking the sweetness of sugar as one, that of invert sugar is 1.2, of fructose 1.8 and of d-glucose 0.7. Saccharin in the soluble form in which it is used is 300 times as sweet as sugar, but does have a bitter aftertaste. So does the sweetening agent cyclamate (sweetness 15 times that of sucrose) though to a lesser degree. The new sweetener, aspartame, has a "pure" sweetness like that of sugar, but is 150 times as powerful. There is even a chemical which is 22,000 times as sweet as sugar. Certain natural berries, called by fancy names like miracle fruit and serendipity berries, carry intensely-sweet proteins.

The advantage of these substances is that they can be used in much smaller quantities in soft drinks and medicines, thus avoiding a big bulk of sugar. Sugar when eaten also means calories, and apart from diabetics, those watching their weight would prefer to use other sweeteners. In other countries special diabetic sweet foods are made that do not contain sugar.

There are specific taste buds or receptors on the tongue for sweetness, which are distinct from others for salty, sour and bitter tastes. To exert a sweet taste, it has been found that a chemical must carry two centres, A and B, which are electrically negative in chemical terms. In addition, A must have the capacity to bind loosely with a hydrogen atom H, to give an AH-B system; further there must be a specific distance, 3 Angstrom units to be exact,

between the AH and B orbits. It has also been postulated that there is a kind of receptor cave on the taste buds into which the sweetener must fit. All this is shown for sugar in the drawing.



Bitter-sweet compounds like saccharin are believed to react at one end by an AH-B mechanism with a sweet receptor, and at the other end with a bitter receptor.

Role of sugar in foods

While sugar is of course a sweetening agent, it has many other roles to play in food. It can tone down any acidic, salty or bitter flavours in the dish, and is used in cooking in this way. The glassy look of boiled sweets, the texture of a sponge cake, the viscosity of kulfi, the body or mouthfeel of soft drinks and ice cream, and the grittiness of mesur pak, peda or dry laddu, all owe a good deal to the form in which sugar is present. In a cake icing, spun candy or sugar-coated cashewnuts, the decorative sparkle is due to fine sugar crystals. In a murabba or a sweet pickle, sugar has a preservative action against microbes, and in acidic products like jams, it enhances the action of vinegar (acetic acid) or citric acid, as we shall see in Chapter 9. The inversion of sugar to glucose and fructose by boiling, acids, or enzymes is important in the preparation of a number of foods like jams and jellies, bread, cakes, rasogolla and jelebi, as is described in Chapter 10. The Maillard reactions which inverted sugar undergoes, as we shall see in Chapter 8, play a prominent role in the colour and flavour of baked foods like bread, chapatis, and nankhatai, of roasted cereals, grains and nuts, and of fried foods like sevian (semiya). The caramelisation of sugar to give a brown colour comes into the picture in the baking of bread crust, the roasting of chapatis, the frying of gulab jamuns, the hard matrix of a chikki and the plastic base of a sesame seed laddu.

SALT

Everyday common salt has a hoary and fascinating history. Four thousand years ago, the Chinese chronicled the preparation of salt from seawater. Roman soldiers were paid in salt, and from saldare, meaning to give salt, was the word soldier itself derived. In Latin salarium means salt money, though today we prefer to get our salaries in other ways. Messer Marco Polo the thirteenth-century traveller noted that in Tibet salt carrying the stamped seal of Kubla Khan was used as money. Salt therefore was once a precious commodity.

Today salt is a plentiful, pure and very cheap item of food. In other countries it may be obtained mainly from solid deposits of rock salt, as in the USA and USSR, from salt lakes (USA, Jordan) or from underground salt springs (Philippines, Turkey). In India we get it from all these sources, but, with our long 5600 kilometre coatline, mainly from sea water in every state that has a sea coast. Sea water or brine is allowed to flow first into a main reservoir from which it is fed to a number of crystallisers (these may be 80 metres long and equally wide, but just 5 cm deep) with a hard beaten floor where evaporation occurs through exposure to the sun. Today plastic liners are used to prevent seepage. As the water evaporates certain less-soluble salts present in sea water crystallise out first, like calcium carbonate and calcium sulphate. Then the bulk of the sodium chloride crystallises, and the remaining bitterns, as they are called, yield on evaporation magnesium chloride, magnesium sulphate and sodium sulphate, mixed with the sodium chloride that remains. The other salts are collected by allowing the liquid to flow into the next crystalliser, leaving the by-product behind. The main salt product is raked into ridges or heaps, and dried in the sun.

Similar methods are used to make salt from salt lakes such as the Sambhar lake in Rajasthan and the Chilka lake in Orissa, and likewise from sub-soil salt springs in the Rann of Kutch, Rajasthan, the Manekudi lake in Kerala and the Vedaranyam swamp in Tamilnadu. Rock salt is only mined in India at Mandi in Himachal Pradesh and being of poor quality, is mainly used to make what are called cattle licks, a blend of various mineral salts that are required nutritionally by cattle.

There are historic local names for the salt varieties made in

India. The kurkutch variety is made in Maharashtra, Gujarat and the Sambhar lake, kuppa and baragara in Gujarat, panga in West Bengal, and the pink kyar and reshta in Rajasthan. All these are of good quality, with 96 per cent or more of sodium chloride and less than one per cent of magnesium chloride. Of poorer quality, with a 90 to 92 per cent true salt content, are mapi and vajni varieties made in all the southern states, Orissa and Maharashtra. The baragara salt made in Gujarat comes out as cubes that are as large as one centimetre each way, in colour white to yellow or grey.

For fine-quality table salt, these salts are further refined. Always there is a little clay and dirt; salt from sea water will carry some magnesium and calcium sulphate, and Sambhar lake salt sodium carbonate, bicarbonate and sulphate. Particularly pure salt is needed for use in drugs and pharmaceuticals, in butter and cheese making, in canning fruits and vegetables and for fish curing. Such purification consists mainly in washing the salt with a concentrated solution of sodium chloride, when insoluble impurities get carried away as a suspension and magnesium sulphate in solution. Next the salt in concentrated solution is treated successively with solutions of calcium hydroxide (lime) and sodium carbonate (soda ash). Thereafter the solution is filtered and the filtrate evaporated in open vessels that carry inclined stirrers revolving at a constant slow speed to yield round, even grains. When these have reached the right size, they are centrifuged free of liquid, dried in an oven and then coated with 0.5 per cent each of paraffin wax and basic magnesium carbonate or tricalcium phosphate to prevent them from absorbing moisture, sticking together, and not flowing really freely during monsoon weather. Dairy salt is made the same way, but no coating is put on; instead the salt granules are sieved and sterilised at 140°C before packing.

Salt in food

To work smoothly, the bod yneeds many metals like potassium, iron, copper, cobalt, zinc, magnesium, manganese and so on in very small quantities of a few milligrams or even micrograms a day. Sodium however represents a major need, and generally it is met in the form of sodium chloride or common salt. An adequate daily intake is about one gram a day, though four times this quantity is actually available in India. In many advanced countries, daily consumptionca n be 10 times what is needed, since almost

every processed food carries salt as a preservative in smaller or larger quantity. Particularly large amounts are put into cheese, butter, meat and bacon.

The sodium in salt helps to keep up a certain pressure in body fluids, which in turn regulates the movement of water into and out of cells; this constitutes the so-called water balance, and it influences body dehydration. Consequently, a high salt intake is conducive to hypertension, a very common condition in advanced countries. Salt also helps the kidneys to regulate the acidity of the blood, and the acid-base balance in the body. The constant beat of the heart is indirectly related to the presence of both sodium and potassium, which play a part in relaxing contracted muscles. Low-salt diets are required in hypertension, kidney irregularity and the ankle-swelling that occurs in pregnant women. On the other hand, cramps in such women call for eating more salt. Those working in very hot conditions, like manual labour in the open summer sun, or in very hot areas like foundries, steel mills, railway engines, and coal mines, may lose so much salt by sweating as to lead to muscle cramp, exhaustion and even collapse; the remedy is to suck salt tablets.

Since salt is eaten by everyone, high or low, and in fairly similar quantities, its use as a carrier of nutrients has been suggested. Attempts have been made to incorporate vitamin A in a water-soluble form into salt, but this has not made commercial headway. Work in India has shown much brighter prospects for the incorporation into salt of iron. This mineral is almost universally deficient in all segments of the Indian population, because of marginal availability in food and very poor absorption from bulky cereal-based diets that are high in phytate, dietary fibre and tannin. Many difficulties have been solved: keeping the iron-carrying salt from going brown on storage, raising the proportion of iron absorbed, and incorporating the iron uniformly into the salt. Field studies have shown that consumption of such salt in practice did raise the blood haemoglobin level in children. Actual production and marketing of iron-fortified salt should prove an important public health measure when instituted.

Salt that carries potassium iodate has long been made in India. This is meant for sale in the foothills of the Himalayas, where in some regions the food and drinking water does not carry enough iodine. As a result, the thyroid gland in the neck begins to swell,

and the eyes bulge out, a condition known as goitre. A high proportion of such congenitally goitrous persons are also found to be cretins, a term used to describe those who show severe mental and physical retardation, and are frequently deaf and dumb as well. Addition of as little as one part of iodine as potassium iodate to 10,000 parts of salt is sufficient to prevent these distressing manifestations.

Animals also need, apart from sodium chloride, other mineral salts. Cattle licks of the right minerals blended with common salt are manufactured in India.

CHAPTER 5

Spices of Life

Spices, Condiments and Herbs

An Indian legacy

NOT WITHOUT REASON has India been called the home of spices, since fifty of them are widely known and perhaps half this number are almost in everyday use. Even in antiquity, sailing ships carried Indian spices to the Middle East and Europe, and it was the lure both of wealth and costly spices that brought western adventurers to this country. Vasco da Gama returned to Portugal with only two of the four ships with which he started, but these contained enough spices and other goods to pay for the voyage sixty times over.

In Western countries it was the preservative action of spices that was of prime importance. Meat could be preserved for even a year without refrigeration by pickling it with cloves, wood smoke, mineral salts and so on. Cured pork and sausages were well spiced. Mustard seed and ground mustard were likewise used to prolong the life of perishable meat foods. In India, while pickling using spices and oil certainly developed into a high art, as Chapter 9 bears witness, spices are even more widely employed in foods cooked every day, where it is the flavour, taste and colour of these materials that are of primary concern. In fact the distinguishing characteristics of the numerous regional styles of cooking in our vast country lie very little in the basic food materials employed, which are rice, wheat, pulses, vegetables or tubers. Rather is it the unique combinations of spices in each region, in each community and indeed in each home that confer on every dish its distinctive character. A Bengali fish curry, heavy on mustard spicing, is vastly different from a Goan vinegar-based vindaloo. A southern tuvar dhal sambhar, redolent of tamarind,

asafoetida and turmeric, is a far cry from a thick *meeta* tuvar dhal finished with a topping of ghee-fried mustard seeds and chopped coriander leaves.

The conversion of the raw spice material to the table or kitchen product usually involves only low technology, such as sun drying or mild natural fermentation or grinding. High technology for the preparation of flavours, oleoresins and colours is a recent development which will be considered later. Sun- or shade-drying is used with a variety of materials: leaves like the cinnamon, buds like cloves, and flower stigmas like those of the poppy to give saffron (zafran). Also dried are whole fruits and berries, like the aniseed, cardamom, jeera, saunf (fennel), pepper and jaiphal (nutmeg), fruit pulps such as the kokam, mango and tamarind, fruits pods like the fenugreek, and even the aril of a fruit such as the javatri (mace). From below the ground for drying come bulbs and rhizomes like the garlic, onion, ginger and turmeric. Once dried, some spices may be subject to further grinding, like the chilly, turmeric and dhaniya (coriander seed). Fermentation of a natural kind to get rid of pulpy material is employed in the preparation of cinnamon bark and vanilla pods. The technology of root incision followed by exudation and collection is necessary to obtain asafoetida (hing). Thus some technology is involved in spice preparation, though this is not of a particularly sophisticated kind.

What do spices contain ?

Like most vegetable organic matter, spices, condiments and herbs in their natural state carry a great deal of water, but except for leafy herbs, the material in the kitchen is almost always a partly- or fully-dried product with a fairly good life on the shelf. Green chillies, green pepper and fresh coriander have 65 to 85 per cent of water, while dried ginger has 60 per cent, dried cloves 25 per cent and dried tamarind 20 per cent. Most other spicy materials have been dried down to a 10 to 15 per cent level of water.

Apart from water, spices being natural organic products, are made up largely of various types of carbohydrates, like cellulose, starch, sugars and so on; fibre, which is also a carbohydrate, can be as high as 30 per cent.

Protein contents are usually well below 10 per cent, except for various seed-derived spices, like methi (26 per cent), mustard (22), jeera (19), ajowan (17), coriander seeds (14), pepper (12) and

cardamom (10). An apparent exception is dry chillies, with 16 per cent protein, but this again is mostly derived from the seeds. The content of fat again is high in seed-based spices, the percentage contents being: mustard 40, nutmeg 36, javatri (mace) 24, ajowan 22, coriander seeds 16, and jeera 15. Other spices, condiments and herbs have below 5 per cent of fat, frequently just 1 to 2 per cent. Minerals, which include calcium, iron, potassium, phosphorus and so on, are usually at a 2 to 7 per cent level, which is a high range for organic matter: common cereals and dhals lie in just the 1 to 3 per cent mineral range. The content of various vitamins is very widely variable from one spice to another and will be discussed later when considering their nutritional value.

But what really distinguishes this class of products is their fragrant, aromatic or pungent character. This is caused by the presence of what are termed essential oils, a term connoting volatile organic compounds of a variety of types. If one can recall college chemistry for a moment, these are classed as terpenes, sesquiterpenes, alcohols, esters, ketones, aldehydes and so on, and sometimes these may carry, apart from carbon, hydrogen and oxygen, nitrogen and sulphur also.

The names of these compounds are amusing and often quite poetic. Ginger carries camphene, zingiberene and phellandrene in two forms, and all are terpenes that have strong odours. The same camphene also occurs in the nutmeg but accompanied by myristicin, an ether, geraniol, an aliphatic alcohol, safrole, a ketonic compound and various other terpenes called pinenes, so the smell and taste of the nutmeg is different from that of ginger. Pinene is rather widely present, in pepper, peppermint, mace, fennel, coriander seed and bay leaves, but other aromatic constituents bring in their own characteristic flavours. Sometimes one flavour dominates : that of menthol (an alcohol) in mint and peppermint, eugenol in cloves and thymol in thyme (both phenols), anethole (an ether) in fennel (saunf), sulphides of an organic nature in garlic, and isothiocyanates (containing both sulphur and nitrogen) in moistened mustard seeds. The final total flavour impact is however almost always a combined one.

Certain spices have components other than those causing the aromatic odour. Thus the bite of chilly on the tongue is due to a non-volatile chemical called capsaicin found in all chillies in greater or lesser amounts, accompanied sometimes by capsanthiu,

another non-volatile compound. Pepper too has non-volatile piperine and chavicine, both of which are broken down by saliva to the pungent piperidine. Methi (fenugreek) has practically no volatile oil, and owes its bitter taste to a saponin and to trigonelline, a nitrogen-containing product. Ginger has both an aromatic volatile essential oil, and a non-volatile compound called zingerone with a pungent 'bite'.

Occasionally a strong colouring matter is present. All chillies carry carotene, an orange colouring matter that has vitamin A properties. The yellow colour of turmeric is from the pigment curcumin, which is developed fully when the rhizome is cured after removing it from the ground. The brilliant orange-red colour of saffron (zafran) is crocin, a sugar-containing compound, while its bitter taste resides in another sugar-based material, picrocrocin.

Condiments used as souring agents carry various acids. Thus tamarind has tartaric acid, kokam hydroxycitric acid, amchur (mango) malic acid, pomegranate seeds (anardhana) oxalic acid, and caper buds rutic acid.

High technology: getting at the spicy principle

In place of using the whole spice with so much of organic material, the spicy principle can be isolated and used more conveniently: a much smaller quantity is needed, it can be solubilised for use and sometimes it is purer too. Volatile material can be distilled away with steam and then employed, but often this will not give the important non-volatile pungent principle. Hence, the technology that has been evolved to get a true concentrate of certain spices is to isolate what is called an oleoresin. This is the solid or semi-solid pungent resin component of the spice, in which the volatile flavour constituents frequently also get trapped.

Oleoresins are obtained by extraction of the dry powdered spice with a solvent like alcohol or acetone in which both the resin and flavours are soluble. The solution is then concentrated carefully under vacuum so as to lose the minimum of volatiles, and every trace of solvent is then removed by very meticulous processing. The yields of oleoresin obtained in this way from various spices are as follows, expressed as a percentage: chillies 15, ginger 6, pepper 11 and turmeric 7. These oleoresins contain the pungent principles of the spice itself at a high level: that from chillies 2 to

3 per cent capsaicin, ginger 25 to 30 per cent gingerol, pepper 40 to 45 per cent piperine, and turmeric 35 per cent curcumin. Thus a tenfold concentration of the active principle has been effected in every instance.

Concentration can be brought about in certain other ways Garlic pods when fresh have over 60 per cent water. Removal of water, or dehydration, using suitable techniques gives a free-flowing powder with about 5 per cent water only, and with all the qualities expected of garlic when used for cooking. If the odour is not required, this can be suppressed in the powder by deactivating an enzyme, termed allinase, which acts on a compound called allicin to generate the odour. Garlic powder, if mixed with four times its weight of salt and a small proportion of an anticaking agent, yields garlic salt. For the tamarind, two types of concentration are used, and one can get either a very thick, very sour black paste of which only a few drops are needed during cooking, or a starchy free-flowing sour powder used by the teaspoon.

Certain other new spice technologies may be outlined. Cayenne pepper is really a blend of three parts of finely-ground dried cayenne or bird chillies and one part of salt. Spikes carrying tender green pepper, or the detached berries, can be pickled and canned in brine to constitute a table relish that is building up a large demand overseas.

Modern technology can upgrade existing practice. Thus turmeric after removal from the ground used to be boiled with water to which cowdung had been added to make it alkaline. This unhygienic material can be substituted with lime water or baking soda. Poisonous lead chromate subsequently used to enhance the yellow colour can be replaced with a solution containing sodium bisulphite and hydrochloric acid.

What are spices, and what do they contain ?

Listed alphabetically on page 79 are the common names of spices, condiments and herbs, and a couple of their Indian names. Also noted are the chief constituents (abbreviated to CC) that confer on them their distinctive flavour and taste. These names, with their poetic and amusing ring, may serve to recall one's college chemistry. Most of these commodities are familiar Indian products, but also included are a few that are imported for use in

manufactured foods, or in the home kitchen to create exotic dishes.

Allspice or pimenta (*seetul, gandamenasu, kattukuruva*) : Round, reddish-brown unripe berries that are dried and sometimes ground. Name derived from its mixed flavour of cloves, cinnamon, nutmeg and black pepper. Ingredient of curry powders, pickling powders, mincemeat spice. CC: eugenol.

Aniseed (*vilayati saunf, shombu*) : Seed, obtained simply by drying whole fruit. Strongly resembles true Indian saunf or fennel. Mostly imported from Europe. CC: anethole.

Arecanut (*supari, adekke, pakku*) : Nuts of a palm, which may be used after simple halving and drying. To improve colour, taste and keeping quality by removing excess tannins and mucilage, the nuts are frequently cured by boiling the whole nut, or halves, or slivers, in an extract from the previous year's operation. Betel nuts are chewed as such, after scenting, sweetening and blending with sugar, copra and other spices, or along with betel leaves and slaked lime. *Kattha*, which is also smeared on betel leaves, is a tannin-rich material derived from the heartwood of the same tree. CC: catechin (astringent), arecolin (stimulant).

Asafoetida (*hing, perungayam*) : Root exudate, collected and formed into 'tears' (balls), mass or paste. In commerce, *hing* is the light-coloured, water-soluble, less aromatic product, while *hingra* is the darker, oil-soluble, more aromatic product derived from a different variety of tree. Mostly imported from Iran and Afghanistan. CC: mixed alkyl disulphides.

Bay leaf (no common Indian name) : Leaf, used fresh. CC: linalool, methyl cinnamate.

Betel *(paan, tambula, vettilai)* : Green leaves of a creeping vine, belonging to the pepper family, which grows all over India. The leaves come in various sizes, shapes, shades of green and degrees of pungency. They are chewed after a meal to stimulate the digestion, usually after being smeared with slaked lime and *kattha* pastes, and folded over arecanut grits. CC: eugenol.

Bishop's weed (*ajowan, omum*) : Both seed (the dried greyish-brown fruit) and fresh leaf are used. CC: thymol.

Caper (*kabra, mullukatari*) : Flower buds of a trailing European shrub. Used green, or pickled in vinegar, to flavour mutton and fish. CC: rutic acid.

Caraway (*shia jeera, seemai shembu*) : Seeds, obtained by drying whole plant and then threshing. Smaller than *jeera*. CC: carvone.

Cardamom (*choti elaichi, yelakki*) : Fruit capsule. Grows on long spikes that take off underground from the stem and shoot straight out of the ground. Nearly ripe fruits are dried with hot air to a dark green colour. White cardamoms are obtained by bleaching with burning sulphur (dioxide) fumes or bleaching powder. CC: cineol, borneol, camphor.

Celery (*ajmoda, shalari*) : Ripe fruit of the same plant that carries salad leaves. Fruit is dried to small seeds, also used as bird food. CC: limonene.

Chillies and capsicum (*mirch, molaga*) : Fruits of several varieties of the family *Capsicum annum* that yield pungent red chillies, pungent green chillies and mild (sweet) bell peppers. Vary in colour (red, green, yellow, white), length (from 1 to 30 cm) and shape (long, thin, round, oblong). All chillies originated in the Americas, and were spread to the rest of the world after Columbus. Introduced into India by the Portuguese, popularised in the 17th century. Used green or dried. CC: capsaicin, a pungent compound present in amounts varying from zero to 2 per cent in all chillies.

Chillies paprika or Spanish pimiento (hardly cultivated in India) : Belongs to the mild *Capsicum annum* group. Fruits, red, medium to small, quite fleshy. Introduced into Hungary through a Turkish invasion, came to be called Turkish pepper or pimenton. Bred in Europe to a low pungency and a brilliant red colour, now also grown in California. Never used whole, only as powders that come in a range of colours and flavours from various countries.

Chillies cayenne or tabasco or bird (no special Indian name) : Varieties of *Capsicum frutescens*. Small, conical, very pungent fruits, dried in the sun or mechanically. Used to make tabasco sauce and Chinese chilly sauce.

Cinnamon bark (*dalchini, lavang patti*) : Bark of several species of true cinnamon and cassia trees. Gutter-shaped pieces are cut from larger trees, and smaller quills (rolls) from smaller trees. Washed, dried and sometimes fermented for two days. Also powdered. CC: cinnamaldehyde.

Cinnamon leaves (*tejpat, talisapatri*) : Obtained from a species

of cinnamon tree. Sun-dried, then packed in bundles. CC: eugenol.

Clove (*lavang*) : Unopened flower bud of a tree 10 metres tall. Picked green, sun-dried to a dark colour. Name derived from its resemblance to a nail (French, clou). Pale brown or whitish cloves result from undesirable fermentation. CC: free eugenol (80 per cent) and eugenol acetate in the bud button, and more of the acetate in the stem; however the odour is due not to these but to trace constituents.

Coriander leaf (*kothmir*) : Entire tender plant is aromatic. CC (of flavour): decylaldehyde.

Coriander seeds (*dhaniya*) : Seeds lightly roasted, often powdered. CC (of flavour): decylaldehyde.

Cumin, white (*jeera*) : Fruits dried to yellow-to-greyish brown seeds. Flowers of plant are white or pink. CC : cinnamaldehyde.

Cumin, black (*kala jeera, kalunji*) : Seeds of a plant species different from true jeera, with pale blue flowers. Not common in India. CC: carvone, limonene.

Curry leaf (*kari patha, barsanga*) : Leaves, used fresh or lightly-dried. CC: sabinene, pinene, dipentene.

Dill (*sowa, surva, sabasige*) : Dried ripe seeds. Indian dill is from the same plant family as European dill seeds, but from a different species, with broader and shorter seeds. CC: dill-apiole, carvone, phellandrene. European dill seed has no dill-apiole and twice the carvone content.

Fennel (*saunf, shombei*) : Dried ripe-fruit seeds. Sometimes confused with aniseed (*vilayati saunf*). Flavour depends on the plant sub-species and climate in which grown. CC: anethole.

Fenugreek (*methi, venthiyam*) : Dried ripe pod carrying 10 to 20 small, hard, oblong seeds. CC: carries practically no volatile material, but does contain a bitter alkaloid and trigonelline, which on heating is converted into the vitamin, niacin.

Garlic (*lassan, vellaipundu*) : White underground bulbs, lifted and cured for a few days in the shade. Consist of sectional 'cloves'. CC: dialkyl disulphides and trisulphides, derived by hydrolysis of allicin, the major odour principle.

Ginger (*adrak, inji*) : Rhizome (root), used either green (*sunti*) or sun-dried (*adrak*), either peeled or unpeeled. Contains both

aromatic volatile oils (CC: camphene, zingiberene) and pungent non-volatile constituents (CC: zingerone).

Kokam (*murgala*, *kachampuli*) : Fruits. Globes (3-cm) with 6 large seeds. Used as an acidulant, either as such, or by soaking the outer rind repeatedly in the juices of the pulp, and then sun-drying the mix. Seeds contain a fat (kokam butter), used as an emollient and as a hard fat in soapmaking and confectionery. CC: hydroxycitric acid (sour).

Mace (*javatri*, *jaiphal*) : Scarlet aril that envelops the black seed shell of the mace fruit, and becomes visible when the ripe fruit bursts open. The aril is carefully pried away and pressed flat and thereafter dried to give a red-brown, translucent, brittle material, which is cut into the strips of commerce. Flavour resembles that of the nutmeg, but is more refined. CC: pinene, camphene.

Mango, green (*amchur*, *manga podi*) : Sun-dried slices or powder of unripe fallen mangoes of many varieties. Keeps for a year or so in airtight bottles. Used as a souring agent in Indian cooking. CC: malic acid.

Mango-ginger (*am haldi*, *mangai inji*): Neither mango nor ginger, but the dried rhizomes of a plant of the turmeric family. Flavour lacks the pungency of ginger, but resembles that of raw mango. CC: ocimene, myrcene, limonene.

Marjoram (*marwa*, *marugu*) : Dried grey-green leaves with or without the flowering tops. Often used in flower garlands and venis, and in Western-style cooking. CC: carvacrol, linalool.

Mint (*pudina*, *muthina*) : Fresh leaves. Used to make chutneys and sauces. There are at least 40 species of *Mentha*, of which three are important in India, and this includes a variety imported from Japan. Peppermint oil, obtained from mint, is usually used after crystallising away half the menthol. CC: menthol, menthyl acetate and menthone.

Mustard (*rai*, *sarson*) : A small, round, reddish-brown or purple-black oilseed, four varieties of which are common: yellow *sarson*, brown *sarson*, *toria* and *rai*. The brown varieties are used extensively in Indian cooking, and the yellow and brown varieties as a source of a pungent cooking oil popular in Bengal and Punjab. Two varieties, Banarsi *rai* and *safed rai*, which are particularly pungent, are ground with water to give Western-style table mustard pastes. The pungency is the result

of an enzyme action, and must be developed by slowly grinding the seeds with water. Roasting the seeds or frying them, as in Indian cooking practice, destroys the enzyme and suppresses pungency. CC: various thioglucosides which are enzyme-hydrolysed to several pungent alkyl isothiocyanates.

Nutmeg (*jaiphal, jajikai*) : Peach-like fruit dried down to the kernel. Greyish-brown with white furrows. Mace or *javatri* is the aril of the same fruit, usually removed before the nutmeg is dried. CC: myristicin, geraniol, pinene, camphene.

Onion (*piyaz, irulli*) : Bulb, partly dried but still succulent, colour from red to white. Extensively used in cooking, or raw as a salad, or for pickling. The pungency of an onion is developed only when it is cut, by enzyme action on a flavourless precursor. Boiling or shallow frying in oil makes the product translucent through starch gelatinisation, and destroys the pungency both by killing the enzyme and volatilising the acrid constituents. Further frying causes browning, and a sweet taste develops by caramelisation. CC: alkyl disulphide.

Oreganum (*sathra, miranjosh*) : Dried, light green leaves and tops. Not common in India. An essential flavouring constituent of many Mexican foods like chilli con carne, and the tamale and taco. Resembles marjoram, sage and thyme in flavour. CC: thymol, carvacrol, terpenes.

Paprika : See Chillies, paprika.

Parsley (*ajmod, kothambelari*) : Leaves, fresh or dried, and seeds. Mainly a temperate crop. The greens constitute a delicate garnish resembling coriander. The seeds carry a fatty oil of disagreeable flavour and odour. CC: apiole, alpha-pinene.

Pepper, black (*kali mirch, kara menasu*) : Sun-dried, unripe berry growing on the spikes of a climbing vine. Fully-mature but unripe, greenish-yellow berries on drying yield black or brown pepper; ripe, orange-red berries yield white pepper if the skin is removed, either before or after the drying operation, by steeping in water or steaming. Both forms of pepper can be ground. CC: piperine and chavicine, both of which on hydrolysis with saliva or water yield the pungent piperidine, which gives pepper its bite. The odour is due to alpha- and beta-pinene, phellandrene, other terpenes.

Pepper, long (*pipli, hipli*) : Dried fruit of a climbing wild plant. Used as a spice, like pepper, but is less pungent.

Peppermint (*gamathi pudina, vilayati podina*) : Leaves of a certain variety of mint, not common in India. Source of peppermint oil with its strong agreeable odour and 'cooling' mouth-feel. CC: menthol, limonene, menthone.

Pomegranate (*anardhana, dalambi*) : Dried angular seeds (fruit globules) especially from a wild variety called daru. Used in the form of grits or powder as a souring agent in north Indian cooking. CC: oxalic acid.

Poppy (*khuskhus, gasalu*) : Tiny seed of the opium poppy. Used in Indian cooking for its nutty flavour and crunchy texture. Carries no morphine narcotics, except through contamination with particles of the capsules in which the seeds are housed.

Saffron (*zafran, kesari, kunkuma*) : Dried, light, deep-orange. strongly-flavoured stigmas of a crocus flower of lavender colour that grows in Kashmir. After sun-drying, the stigmas are sorted by hand to give the best whole grade (*shahi*); this is followed by floating the rest in water twice, each time collecting the heavier particles (*mogra, laccha*). CC: picrocrocin (bitter taste) and crocin (orange colour).

Sage (*sefakuss, salvia*) : Dried grey-green leaf of a variety of salvia. Hardly known in India, but is widely used in Southern Europe to flavour meat and cheese dishes. CC: thujone, linalyl acetate, camphor; tannin (astringent component); picrosalvin (bitter taste).

Spearmint (*pahadi pudina*) : Leaves of a mint variety, without the 'cool' mouth-feel of peppermint. Not common in India. CC: carvone, terpenes.

Tamarind (*imli, puli*) : Ripe, dark-brown, fibrous pod-fruit, used fresh, or after drying and deseeding. Widely used as an acidulant, especially in south India. CC: tartaric acid, glucose, fructose, pectin.

Tarragon or Estragon : Dried leaves and tops, with an odour resembling aniseed. Not grown in India. Used to flavour vinegar, pickles, mustard. CC: methyl chavicol, phellandrene, ocimene.

Thyme (*banajwain, marizha*) : Dried leaves and flowering tops, brownish-green. Grows only at high altitudes in India, but is common in the western world. Used to season tomato soups, clam chowder, poultry meat. CC: thymol.

Turmeric (*haldi, manjal*): Dried, boiled and polished rhizome

(swollen underground stem). Extensively used as fingers or powder in Indian cooking for its flavour and colour, and in religious ritual (orange being a sacred colour), cosmetics (as hair remover, and to make kumkum or sindhoor) and medicine. CC: curcumin (colour), zingiberene, other ketonic sesquiterpenes, borneol (flavour).

Vanilla (*vanilla*) : Cured fruit-pods of a climbing variety of orchid. The Malagasy Republic (formerly called Madagascar) grows three-quarters of the world crop; little is raised in India. During fermentation-curing, the vanilla odour develops by hydrolysis of a sugar-vanillin precursor. Widely used to flavour ice-cream, chocolate and many sweet foods. CC: methyl vanillin; both methyl and ethyl vanillin are made synthetically.

Nutritive value

Since spices, condiments and herbs are consumed in very small quantities every day, their contribution by way of the macro elements of nutrition, namely carbohydrates, proteins and fats, cannot obviously be of any significance. Occasionally, however, an exceptionally high level of a mineral, or even more so of a vitamin, which are the two micronutrient groups of nutrients, may have some meaning in nutrition. This is especially true where the material is one which is used in fair amount in cooking.

Table 5.1 shows some micronutrient minerals and vitamins present in spice materials, listed roughly in the decreasing order of their use in an Indian kitchen. Calcium is high in jeera, dhaniya and curry leaves, and iron in green chillies and dried red chillies. Phosphorus is present in good amounts in mustard seeds and curry leaves, but many other spices (dhaniya, jeera, garlic, red chillies, chilly powder, onion and turmeric) carry sizeable quantities. Coming to the vitamins, thiamine occurs in chillies and their powders, mustard seeds, onion and garlic; riboflavin again in chilly products and mustard seeds; and niacin in chilly powder, mustard seeds and turmeric powder. Rich sources of vitamin C are green chillies, dried red chillies, chilly powder, and turmeric powder, while curry leaves and chilly powder are good sources of vitamin A. Thus use of these materials in everyday cooking in reasonable amounts cannot but contribute cumulatively towards the needs of vitamins and minerals of the human body.

TABLE 5.1

Micronutrients in some common Indian Spices

Material	*As g/100g edible material*				*As mg/100g edible material*			
	Calcium	*Phosphorus*	*Iron*	*Thiamine*	*Riboflavin*	*Niacin*	*Vit. C.*	*Vit. A*
Onion	0.3	0.29	Trace	0.42	0.06	0.6	14.7	0.05
Garlic	0.1	0.42	0.01	0.68	0.08	0.7	12.0	0.05
Ginger	0.1	0.15	0.01	0.05	0.13	1.9	12.0	0.05
Turmeric	0.2	0.26	0.05	0.09	0.19	4.8	49.8	0.05
Chilly powder	0.1	0.32	0.01	0.59	1.66	14.2	63.7	1.85
Green chilly	0.03	0.08	1.2	0.19	1.18	0.5	111.0	Trace
Red (dried) chilly	0.16	0.37	2.3	0.93	0.43	9.5	50.1	0.18
Mustard seeds	0.3	0.79	0.01	0.65	0.45	8.5	22.1	0.06
Tamarind	0.2	0.11	0.01	Nil	0.07	0.7	3.0	0.03
Curry leaf	0.8	0.60	0.01	0.08	0.21	2.3	4.0	3.78
Dhaniya (coriander seed)	0.8	0.44	0.01	0.26	0.23	3.2	12.0	0.05
Jeera (cumin seed)	0.9	0.45	0.05	0.73	0.38	2.5	17.0	0.05
Adult daily requirement	0.5	(0.5)	0.024	1.4	1.7	19.0	40.0	0.75

Physiological aspects of spices

Spices affect many body functions. In the mouth they exert a mildly irritating action, increasing the flow of saliva and thus enhancing digestion. The antiseptic qualities of most spices clear the mouth of bacteria and keep the teeth clean. In the stomach, the carminative action of spices in expelling gases and relieving distention has been traced to weak closure of the oesophagal valve and relaxation of the sphincter. Spices are mild stimulants of the heart and perhaps of the lungs, considering that many are quite obviously exhaled in the breath. The stimulation of the body enzymes which regulate life processes by certain spices has been demonstrated. Nutmeg (jaiphal) and saffron (zafran) enhanced the activity of two enzymes, pepsin and rennin, that digest protein in the body. However, excessive spicing, for example with chillies, could encourage gastritis or acid stomach.

The antimicrobial or antiseptic properties of many spices are well documented experimentally. Allicin, present in garlic, has a killing action against a very wide range of bacteria, and markedly reduces the actual bacterial load in experimental animals. It is also active against fungi. Curcumin, the yellow colouring matter of turmeric (haldi) has likewise a powerful antibacterial action, and asafoetida destroys coliforms and anaerobes in the caecum. Similarly the suppressive powers of many other spice oils has been proven, such as those of ajowan, aniseed (saunf), asafoetida (hing), clove, cinnamon, onion and pepper (even against dangerous organisms of the *E. coli* group). In the body, such antibacterial action could help to reduce the flora in the large intestine, thus reducing gas formation there. Another desirable thing that probably also occurs is the selective stimulation of acid-forming lactobacillus species, an effect known to occur when curds are consumed.

The antiseptic properties of spices also lend them a preservative value when used in foods. Mustard seed and mustard oil perform in this way in Indian pickles, and cloves and cinnamon in murabbas and fruit preserves. The preservative action of pepper in meat storage is historical knowledge. The curcumin of turmeric is an antioxidant that can prevent the food going bad by oxidative spoilage, a very common occurrence if an oil is present. So does a material present in betel leaf called chavicol. Spoilage microbes are more easily destroyed in an acidic environment, and the various souring agents used in foods, like tamarind, amchur,

kokam and anardhana, could assist in this way. Kokam has actually been shown to extend remarkably the keeping quality of fresh fish, as does garlic for pork.

Certain medical benefits of spices have been proved. Turmeric volatile oil markedly reduced the secretion of hydrochloric acid in the stomach. Curcumin (from turmeric) lowered the levels of blood and liver cholesterol, and has shown indication of being of value in the management of diabetes. Garlic was shown to be of therapeutic use in treating the neurological effects of leprosy, perhaps by assisting in the transport of the vitamin thiamine across the cell membranes. Garlic has also been demonstrated to reduce hypertension in human subjects, and to reduce the level of cholesterol in the circulating blood. Capsicum (the globe chilly) has a beneficial effect on peptic ulcers, healing them and even suppressing their formation. Onions whether raw, boiled or fried increase the blood fibrinolytic activity. Clove oil has been shown to act on the central nervous system. Asafoetida has a sedative effect. Caraway oil expels hookworms, and is effective against scabies of the skin.

However, undesirable effects have also been recorded for certain spices. Consumption of safrole, a major constituent in the oils of leaves of the camphor tree, star anise (anasphal) and sassafras (an aromatic root), and a minor one in those of nutmeg (javatri) and cinnamon leaf, leads to liver changes that are suggestive of toxicity. Accordingly its use as a flavour in soft drinks has been discontinued. Nutmeg (javatri) and mace (jaiphal), both parts of the same fruit and containing myristicin as a major component, lead in small doses to nausea, constipation and stupor; use of a teaspoonful of either causes fits and hallucinations by disordering the mind. Mustard seed and mustard oil owe their pungency to organic isothiocyanates, which are known to induce goitre, especially when the food is deficient in iodine. A similar goitrogenic effect has even been noted for the volatile oils from the onion and garlic. Quite a few spice oils are irritating enough to the skin to cause dermatitis, such as those of the cinnamon and clove.

Spices as medicines

All that has been said so far are matters of experimental fact and observation. Tradition attaches all manner of benefits to every spice, condiment and herb, and they are important ingredients in

pharmacopoeias of the Indian systems of medicine. Some of the medical applications of spices in India will now be set down. Since practically all spices are appetisers, stimulants and antiseptics, these qualities are not repeated under each.

Aniseed (*shombu*) : Against gas, for asthma, to destroy head lice
Asafoetida (*hing*) : As a sedative, in indigestion
Bishops' weed (*ajowan*) : Against diarrhoea and dyspepsia
Caraway (*shia jeera*) : In child colic, against nausea
Cardamom (*elaichi*) : Against sore throat, to sweeten breath; a mild diuretic which stimulates urine flow
Celery seeds (*ajmoda*) : Popularly used against rheumatism and arthritis; known to contract the uterus
Chillies (*mirch*) : Against indigestion
Cinnamon (*dalchini*) : To check nausea, vomiting, diarrhoea; used in toothpastes
Clove (*lavang*) : Favourite toothache remedy, relieves phlegm; used against nausea, indigestion, gas
Coriander seed (*dhaniva*) : Flavourant added to purgatives like senna and rhubarb; a mild diuretic
Cumin (*jeera*) : In indigestion, diarrhoea
Dill (*sowa*) : As dill water, given in child indigestion and to women after childbirth
Fennel (*saunf*) : Against gas and bowel gripes, and in child indigestion
Fenugreek (*methi*) : Given for rheumatism, and to woman after childbirth both to check diarrhoea and stimulate breast milk flow
Garlic (*lassan*) : In afflictions of the lungs, throat, stomach (ulcers) and kidneys: externally the oil is applied in skin wounds and diseases, in earache and as a chest poultice
Ginger (*adrak*) : In indigestion and against gas and as an aphrodisiac; as a flavourant of many medicines
Mace (*javatri*) : In digestive problems, used in very small amounts
Mustard seed (*rai*) : An efficient emetic (vomiting agent) against poisons; externally a well-known poultice, but contact for too long can lead to skin inflammation
Nutmeg (*jaiphal*) : See Mace above. Too large a use of nutmeg or mace can cause fits and hallucinations (see page 88)

Onion (*piyaz*) : To expel phlegm, stimulate the urine and control dysentery

Pepper (*kali mirch*) : For afflictions of the throat and respiratory tract

Poppyseed (*khuskhus*) : In obstinate constipation

Turmeric (*haldi*) : Mild laxative; used to relieve discharges from the nose and eyes, and against sore throat; externally applied in pains and bruises, and by women to keep the skin soft and prevent hair growth. Burnt turmeric is a common toothpowder.

The traditional use of spices are well entrenched in the country, and it is possible that some at least will be confirmed by future scientific experimentation, and their mode of action in the body brought to light.

CHAPTER 5

Cups That Cheer

Tea and coffee

TEA

Origin

EVERYWHERE IN THE world can be found a popular beverage known either as tea or chah. Both words have a Chinese origin: tay in the Amoy dialect and chah in the Cantonese, and tea drinking in China is believed to go back 4500 years. It was commercial pressures that led to the raising of tea in India. The East India Company had by 1833 lost its hold over the tea trade in China. It was anxious to develop an alternate source of supply from India, and a committee to examine this was consituted in 1834 by Lord William Bentinck. At the experimental farm set up in Assam, Chinese tea seeds and plants, called bohea, were initially raised. Meanwhile Major Robert Bruce of the Bengal Artillery had observed that a hill tribe in Assam, the Singphos, traditionally cultivated tea plants. In the event, these local varieties, called viridis, proved to be well adapted to cultivation, and of better quality than the Chinese imports. Within the short space of a couple of years Indian tea leaves of high quality were exported to London, and business companies were set up to foster commercial tea plantations. Today India is by far the largest tea-growing country in the world: it provides some 5 lakh tonnes of tea out of the world total of about 13 lakh tonnes, to which Sri Lanka and China each contribute approximately 2 lakh tonnes.

Tea types

The tea plant grown in China is slow-growing, sturdy and resistant to cold, with a low yield of dark green leaves which give rise to a tea decoction with a good aroma but poor body. The indigenous

Assam tea plant is quick-growing, and there are varieties that give either dark green or light green leaves. The latter type are prolific yielders of leaves, and the tea quality is excellent. Today numerous crosses between Assam and Chinese tea plants have been evolved for various qualities of tea. Despite this, all finished teas are always blends of different lots of processed tea leaves. Even trees from the same estate will not give a uniform quality from year to year, or even from season to season. Experienced and highly-paid tasters rinse their mouths with a brew prepared under strictly standard conditions, and rate each lot for various attributes. Some 30 samples may be chosen from the blender's stocks as potential components for examination by tea tasters. According to their rating, a small quantity of a blend will be made and again evaluated by the tea taster, and also for other characteristics important to the housewife such as uniformity in quality, flavour and weight. Thereafter large amounts of appropriate blends are prepared by mixing in machines.

Flavour on the one hand, and body, strength or colour on the other, are generally opposing characteristics. In general tea plants grown at high altitudes, near Darjeeling in the north-east or on the Nilgiri hills in the south-west, have the potential to yield finished teas of the most delicate flavour. At the other end of the scale, tea dust that is grainy, almost black in colour and free of fibre, gives a brew of quick, rich colour and strong, rather acid flavour. In fact, a 2-minute extraction of dust tea will yield a brew much stronger then even a 15-minute extraction of say Broken Orange Pekoe. But as we shall see, many factors throughout the several processing stages influence the colour, taste and flavour of the final brew.

Tea colour, taste and aroma

Three major constituents present in tea leaves determine final tea quality. Tannins are the most important of these, and are the astringent materials found also in areca nuts, kattha paste, jamun fruit and so on. The second is caffeine which is present also in coffee and cocoa, and gives all these beverages their 'pick-up' or stimulant value. The third is pectin, present also in fruits like the apple, mango and jack; as we shall see in Chapter 10, it is this material which confers a jelly-like binding quality on jams and jellies.

Fresh green tea leaves contain tannins, and an infusion made from them is colourless and has an astringent, bitter, metallic taste. Those familiar with Chinese green tea, which is made from leaf that is not fermented like black tea, but simply dried, will recognise these traits. The first step is the oxidation of these tannins by enzymes present when the two come into contact following rupture of the leaf cells. This is a fairly rapid process, and these primary oxidation products, or POP, are what give a good brew its characteristic bright amber colour and lightly astringent taste. Two types of colour bodies are recognised: the yellow theaflavins and the red-yellow thearubigins, and ideally these must be present in a ratio of 1:12. The aroma of tea is due to volatile aromatic constituents that are partly present in the leaf, and partly arise during oxidation and fermentation. Like many other food aromas, tea aroma is an extremely complex mixture of many classes of chemical compounds, with none really predominating. These include saturated and unsaturated aldehydes, alcohols, acids, phenols, and terpenes, the totality of which gives tea brew its delightful and characteristic fragrance.

Let us return to POP, the primary oxidation products. The reactions do not stop here; under the influence of oxidising and polymerising enzymes, they proceed further but more slowly to yield small polymers, and even more sluggishly to give rise to large polymers. Since these polymers are not soluble in hot water, the brew becomes dark brown in colour, dull and without sparkle or body, and lacking a touch of astringency in taste: altogether an unappetising tea. The various processing steps are designed to maximise the desirable POP level, and to prevent further undesirable reactions.

It was long believed that the second important constituent, caffeine, was simply inert, passing unchanged from the green leaf to the processed tea leaves and thence being extracted into the brew. However it has recently been found that some of the caffeine does react with part of the POP to form salts that are soluble in hot water and bitter in taste.

The third constituent, pectin, also plays an indirect role in the formation of POP. An enzyme present in tea leaves and buds breaks down pectin to pectic acid and methyl alcohol, which being volatile escapes during the processing of the leaf. Breakdown is normally a slow reaction, but if the pectin content is high, as it

is in certain tea leaves, the jelly-like nature of pectic acid may restrain the free diffusion of oxygen in the leaves and retard POP formation. In fact for leaves known to be high in pectin content, the rolling step is made fairly drastic so as to accelerate oxidation. Formation of pectic acid at a later stage actually retards the development of further polymers, and is thus a desirable thing.

We are now ready to look into the many steps by which green leaves are transformed into the deliciously fragrant material that we buy in packets.

From green plants to black leaves

Plucking is the first step. Two leaves and a bud are pinched off, at intervals of some 10 days, to give 5 or 6 pluckings in a season. This portion yields higher levels of the desired tannins, caffeine and other water-soluble materials than leaves or stalk further down the stem. The plucked portion is thrown into baskets hung on the picker's back. There is a deliberate attempt to pack the pickings loosely, avoid exposure to the sun and unload them gently in the factory: this is to prevent bruising, which would start off the chemical reactions too early.

In the next step, called withering, the turgid leaves are converted into a rubbery state that will permit them to be twisted later without breaking. The leaves are spread on racks and dried using currents of air, either natural or artificial, for something like a day to reduce the level of moisture in them. The operation is fairly critical: too little withering will cause poor subsequent rolling, and too much withering will impart a deep colour to the tea infusion,but at the expense of flavour and taste: in fact a sour note will develop.

Rolling is the next step and it has several functions. One is to rupture the leaf cells, thus squeezing out as a juice the tannins, caffeine and so on, as well as the enzymes that set to work on them. The leaves are given a twist and then broken up. How is this done ? The withered, flexible leaves are passed between two rollers of suitable design for curling, tearing and cutting them, and these are called CTC machines. These operations are carried out gradually in a series of passes, and great care is taken to keep the temperature from rising, and to see that the room is both cool and moist. The degree of rolling varies with the material, less rolling being required for leaves that are either very succulent or rich in enzymes.

Next in order is fermentation, perhaps the most important of the various steps in developing a tea of high quality. During fermentation, conditions for desirable enzyme and oxidation reactions must be provided. The rolled leaves are spread out about 40 mm thick on cement or aluminium surfaces at temperatures between 27 and 32°C, and kept undisturbed for periods ranging from 2.5 to 4.5 hours. Too thin a spread will lead to a high rate of evaporation and hence a low temperature, and too thick a spread to less evaporation, a higher temperature and less oxygen availability. Too compact or dense a spread again reduces oxygen availability, and this may be practised with coarse but never with fine leaves. Too long a period of fermentation will develop colour at the expense of other qualities. Hence a great deal of experience and skill are needed during the fermentation step to bring out the potential of any lot of tea leaves to the highest degree.

Next the fermented leaves must be dried. This operation serves initially to promote the final, high-temperature enzyme reactions needed to bring out the fullest flavour in tea; later it kills the enzymes present and arrests further reaction completely. Of course drying reduces the moisture level, and a value below 5 per cent has in practice been found to ensure further safe storage. The fermented leaves are passed in trays along a tunnel held at graded temperatures, starting at about 88°C and finishing at 52°C, with a usual passage time of 20 minutes. Accurate drying involves fine control of temperature and moisture evaporation, which brings in such factors as optimum tray loading, air volume, exhaust ducts, and rate of passage of trays through the tunnel, in all of which experience counts for a great deal.

The dried leaves have next to be graded and sorted to separate the various qualities, and ensure a certain range in the size and shape of the leaves. This is done using sieves for sifting, or even by winnowing away the light extraneous matter with a current of air. Customers buying tea are very particular about uniformity in appearance.

It is just as important to ensure the same taste and flavour in the same brand and grade from batch to batch. This is achieved by blending, and as we have seen, such blending is done on the advice and experience of experienced tea tasters who rate each lot, and then again the blend, to ensure a perfect match. Bidding at

tea auctions is also largely determined by taste ratings. Thereafter the tea is packed in either plywood chests, or cardboard cartons, or even paper packets. Great care is taken to ensure that the flavour of the tea is protected, and also that no outside flavour enters the leaves. Sometimes the finished leaves are even dried again to bring the moisture down to the safe 5 per cent level. The chests or packets are lined with aluminium foil, and again with parchment paper (sometimes these are bonded together as a laminate), which has been found to prevent both the entry and the loss of flavours.

Size, shape and flavour determine tea grades. There are a large number of these and some of the better-known will now be described. The first of the whole leaf grades is Orange Pekoe: this is a fancy grade, coming essentially from leaves and some stalks, with no buds, and yielding a fragrant, thin tea. Pekoe is the largest of the leafy grades, derived essentially from well-withered, whole leaf but carrying some cut leaf. Flowery Pekoe is a large, well-twisted leaf.

Next come the broken leaf grades. Of these, Broken Orange Pekoe or BOP is the most popular brand, constituting half of all the tea sold today: it is smaller in size than Flowery Pekoe, but comes from the same stock. Broken Pekoe is about the same size as BOP, but has a high proportion of cut stalk, whose flat ends can be recognised in the material.

Fannings, the third group, are small-sized grades derived either from finer leaf (for example BOP Fannings) or from leaf and tip (such as Flowery BOP Fannings).

Tea dust is the last and smallest of the grades, and is expected to be hard and granular, very black, and free from fibre and grit: inferior dusts are produced by crushing coarse leaf. Tea waste, the poorest of the grades, is what is left after grading is over: waste has very little leaf or dust, and consists of leaf hairs, fibres, and pickings. It is not sold as tea, and constitutes a waste material that may be processed for commercial extraction of caffeine.

In making green tea, the important steps of withering and fermentation used in manufacturing black tea are omitted. The leaves are subject to dry or steam heat for a few minutes to kill the enzymes, after which the leaves are rolled and dried. The major difference from fresh leaves is that some tannins become insoluble, so that a green tea infusion has less tannins than one from fresh

tea leaves, but of course more than in our usual black tea brew.

A cup a day

It is indeed remarkable that use of a product which came into India barely 150 years ago has spread so rapidly that today the tea sold in this country is enough to furnish every adult with one cup of tea every day. This is borne out by dietary surveys in the various states of India. Such surveys show wide usage of tea all over the country, even in the states of south India which are traditionally coffee drinkers. Tea is used in Kerala by 62 per cent of all families, in Karnataka by 61 per cent, in Andhra Pradesh by 17 per cent and in Tamilnadu by 7 per cent. In Gujarat, tea drinking is nearly universal, in Maharashtra only slightly less so. But what is surprising in both these states is that one-third of infants aged 6 to 12 months are given tea, and that in older children from 1 to 5 years of age the figure is between 60 and 85 per cent. Data for other states are not to be had, but it is common observation that tea drinking is much more prevalent in the north than elsewhere.

The nutritional aspects of tea drinking will be considered later along with coffee.

COFFEE

Another recent entrant

The practice of brewing the roasted coffee bean appears to have developed some four centuries ago in the Kaffa district of Ethiopia, which even today grows a fine quality of coffee. Coffee drinking became a part of the nightly prayer rituals in Yemenite sufi circles, through which it was carried to the rest of Arabia and thence to Turkey. From there the habit passed into Europe and England, the coffee houses of London being frequented in the 18th century by artists, poets, and writers like Samuel Johnson and his circle. The word coffee derives in all probability not from Kaffa but from the Arab word *kahwah*, which originally referred to wine, and later to the decoction of coffee.

Its first arrival in India was an accident of history. A muslim saint of south India announced a piligrimage to Mecca, and disappeared into a cave on the hillside. His followers kept vigil outside the cave for many months till the saint emerged again

from the cave, bringing with him seven coffee berries. These he grew on the hills of Karnataka, which are now called the Baba Budan hills after him. The descendants of those original plants may still be seen there.

From this small beginning coffee plantations spread all over the hilly tracts of the south at heights of between 600 and 1500 metres. The plant needs rich sloping land with plenty of rainfall which must flow away and not stagnate. Tall trees are grown to provide shade and mulch, and prevent the erosion of soil caused by run-off water. The highly-branched plant ranges from about a man's height to twice that, with shiny, dark-green leaves resembling those of the common jasmine. In fact the white coffee flowers look and smell like jasmine too. An April "blossom" shower will bring forth a rash of flowers that form a magnificent snow-white layer, as far as the eye can see, which only lasts a few days. Then the shiny green berries start to form, attaining in 6 months a red, cherry-like size and appearance. Each cherry carries two slightly elongated hemispherical beans, and from about the fifth year onwards for another fifty years, each tree yields half a kilo of seeds. The main pest is the coffee borer insect, which is controlled through rigorous insecticide spraying. Plantation owners are quick to spot a tree showing signs of borer attack, and it is ruthlessly cut down and burnt.

Types and kinds of coffee

South India grows two types of coffee, and twice as much arabica as robusta. Each has its own flavour and aroma, which are brought out when the beans are roasted and then ground. The first stage during roasting is a slow release of moisture, but as the operation continues, individual beans can reach a temperature as high as 500°C. The beans darken in colour and become dry, friable and shining in appearance, while a strong smell develops. All these are manifestations of chemical changes. The sugar, starches and other carbohydrates (which form 60 per cent) are either degraded during roasting to various organic acids, water and carbon dioxide, caramelised with the development of dark colours, or broken down to materials with an acid flavour and taste, like furfuraldehyde. The release of organic acids raises the slightly alkaline reaction of raw coffee into a strongly acid one in the brew from roasted coffee, which is why coffee-drinking is discouraged in

those prone to stomach ulcers. In fact optimum roasting of coffee coincides with peak acidity development. The proteins of coffee beans (about 13 per cent) also play their part in coffee flavour, breaking down during roasting to strongly-flavoured chemicals like hydrogen sulphide and dimethyl sulphide, and to various free amino acids which take part in colour-darkening reactions. Coffee beans also carry about 13 per cent of fat, most of which persists unchanged in the roasted coffee, merely flowing out of the ruptured cells (in which it is stored in the raw bean) to spread itself evenly in the roasted product. A small part is broken down by the intense heat of roasting to pungent products like acrolein and carbon dioxide. Coffee owes its stimulant action to two compounds. Caffeine occurs to the extent of one per cent in robusta beans, and at twice this level in arabica. Trigonelline seems to be at a 1.0-1.2 per cent level in both. Roasting hardly affects both these alkaloids : being both stable and water-soluble they pass easily into the brew.

An important product deriving from a number of constituents during roasting is carbon dioxide gas. A good part of this is driven off by heat, but roasted beans and coffee powder still carry 1.5 to 2.0 per cent of trapped carbon dioxide. Roasted beans hold the gas better than powder does, which may be one reason why beans can be stored for longer periods with their flavour intact than can powder. Green coffee beans store even better before roasting, especially if held dry so as not to absorb moisture. Green coffee that still retains its translucent protective parchment skin, if properly dried and stored away from moisture, can be held unchanged in storage even for years.

Grading coffee

We have noted that arabica and robusta have their inherent quality characteristics. Many other factors come in. Beans can be naturally of different shapes : pointy, boat-shaped with the ends curling in, long or short, plump or round. A small percentage of coffee is round in shape, with only one seed in the berry: this is termed Peaberry and it fetches a premium price for its apparently better quality. Elephant seeds are really two seeds fused into one. A triage fraction consisting of broken and immature seeds can also be separately collected during sorting and grading. Minimum imperfections mean better quality, and these are rated in terms of the

shells, quakers, broken beans, small pods and stones present in any lot.

Bean colour is an important index to evaluate off-flavour. A blue to blue-green colour is considered most desirable for eventual prime cupping quality. A pale white or grey bleached-out colour indicates inferior quality, while a basic brown colour with multi-colour patterns denotes a bean that is more than a year old. Insufficiently-dried coffee beans have a slightly different bluish-green colour that fades rapidly. Overripe beans look reddish, and immature ones smooth and yellow. Black beans are a sign of disease, and since they badly affect coffee flavour, they are usually picked out and discarded.

To test the quality of a lot of coffee, small samples are roasted and the beans cut open. A clearly-visible chaff is termed a brilliant roast, brownish surfaces indicate poor bean development, and dull surfaces mean a mediocre brew. Aroma is also examined as a determinant of quality. From the roasted material, a standard brew is prepared and the cupping quality assessed by experts through smell, taste, and flavour.

From berry to bean

After six months of green growth on the tree, the coffee berry turns yellow; a few days later a red tinge appears, and in a week the berry turns bright red. Picking must be done in the next few days, since otherwise the fruits turn dark and soft, and prime coffee flavour will be sacrificed. All fruits do not mature at the same time, so repeat pickings are ideal, though expensive. Actual pickings will therefore consist of berries at various levels of ripening, including some rather dry, hard fruits.

Initial sorting of berries is done in sinkers, a U-shaped device in which heavier dry berries, stones and dirt sink to the bottom. Most berries are swept along by the water and sorted into small and big sizes using a screen. Ripe fruits, both small and large, are processed using wash water, and dry fruits by dry methods. One can have a 90 per cent washed coffee, or a 100 per cent dry-processed coffee, or any blend in-between.

Pulping to remove the soft fruity portion is the next step. This is done by passing the berries between a smooth disc which stands still and is called a breast, and a moving disc with a rough surface. The pulp is stripped off, and the bean is carried away in a stream

of water.

Clinging to each bean is a sticky mucilage which must be removed to facilitate handling and to prevent enzyme infections that lead to off-flavours. Mostly this is achieved by natural fermentation in large concrete or wooden tanks which also carry yeast and bacteria from previous operations. In a period of about 1 to 2 days the mucilage is totally broken down, and the seeds are dried (sometimes after a quick wash) either in the sun or on wire trays exposed to warmed air. The moisture level, which is 52-54 per cent to start with, comes down to a 12 per cent level. This is important to ensure both subsequent storage and good flavour, and the moisture level is judged by such traditional criteria as biting, thumb-nail scratching and colour (a light greenish-blue). Washed coffee takes a week to dry, natural coffee thrice as long.

The last step is to remove the tough skin or parchment that encases the two beans. This is called hulling, and it is essentially a process of friction among beans achieved in a long tube in which rotates a screw with helical threads on it. The parchment is shorn away in pieces, which are removed with a current of air, and the coffee beans emerge.

Roasting, grinding and percolation

In south India, roasting was once a home operation in hand-turned revolving metal drums over charcoal fires. Today coffee roasting is a commercial exercise, either in small electrically-heated revolving units, or in long continuous roasters with perforations that convey hot air. Usual roasting temperatures are about 180 °C, but individual beans may attain twice or even thrice this temperature. Not only is all the moisture (12 per cent) removed, but another 5 per cent of weight is lost by creation and expulsion of gases and volatile organic materials. As we have seen, a complex series of reactions occurs to yield both a dark colour and a rich, characteristic and penetrating smell: one can hardly carry a packet of roasted and ground coffee in secrecy !

Grinding roasted beans into smaller particles will ensure better brew extraction. Finer grinds carry a higher amount of solubles and colloidal insolubles, but of course if too fine, powder may pass through and show up as grittiness in the brew. In commercial language, the terms percolation grind (coarse), regular grind, drip grind and fine grind are used. Over-roasted beans give more fine

particles than lighter roasts, and old beans more fines than new. Freshly-roasted beans are very leathery and difficult to grind, and they must be cooled thoroughly to achieve brittleness. A great deal of carbon dioxide gas is released during grinding of a large bulk of roasted coffee beans, so a well-ventilated place is necessary.

Brewing of coffee powder in the southern home is done in a traditional brass or stainless steel unit, in which the coffee is tamped down on the perforated base of the upper vessel, which is tightly affixed to the lower unit. Boiling water is gently poured over the metal tamper covering the coffee layer and percolates down in 30 minutes through the bed of coffee to give a very strong, dark, aromatic brew, drunk with plenty of milk and sugar. In Italian-style espresso units, the powder is held in a loose aluminium perforated funnel, and the boiling water or steam from the lower vessel passes through the layer and then via a tube into the receptacle above, actuated through internal pressure developed by the presence of an air-tight rubber gasket. A finer grind of coffee can be used than for downward percolation. In vacuum coffee makers, popular in the USA, two glass bowls are kept one over the other, and the top one carries the coffee in a cloth bag or filter-paper thimble; water boiled in the lower vessel is forced by steam pressure into the top one and extracts the powder, the decoction being sucked back into the lower vessel by vacuum when the percolator is removed from heat.

Instant coffee

A very strong brew is first made by percolation of roasted coffee grounds successively in a battery of tall extractors using very hot water. The brew gets more and more concentrated as it passes along, and also purified of gums and oils. The final extract has about 70 per cent water, and this is removed by spraying the brew as very fine atomised particles from the top of a chamber into a mass of very hot air that is blown in using fans, when a fine light powder with below 3 per cent moisture is produced. The important thing is to make sure that the flavour is retained as much as possible. There are many tricks of technology to ensure this, and in some installations even the volatiles that go out with the water are recovered and put back into the product. Soluble coffee powder is extremely hygroscopic, and must quickly be packed completely airtight in screw-cap bottles or laminated pouches.

Even transferring the powder from a pouch to a bottle in the home must be rapidly done to avoid a sticky mess.

In other countries, new methods of removing water from the brew have been developed. Freeze-dried coffee is made by first freezing the brew and then removing ice by applying vacuum, an expensive procedure. In foam drying, the brew is first made to foam at room temperature, and then vacuum-dried. Vacuum drying at slightly higher temperature is also known.

Coffee in many forms

Chicory has long been popular for 25-50 per cent admixture with coffee powder, lending a slight bitterness, colour and body to the brew. Chicory is the root of a plant resembling the beetroot that is grown in Coimbatore, the Nilgiris, parts of Kerala and Jamnagar. The green roots, when crushed, sliced and dried, can be stored without spoilage, and are roasted and ground before mixing with coffee powder. Barely a sixth of the 4500 tonnes of chicory powder made in the country is used here, the rest being exported.

Blended coffee-chicory powders in instant form, made just like instant coffee itself, are also available.

Mixtures of coffee solubles, milk solids and sugar, in the form of thick sticky pastes, are also being marketed. These are ready to drink with simply the addition of hot water.

People with heart ailments are advised against use of stimulants like caffeine. Decaffeinated coffee for them is made by extraction of green beans (from which mucilage has already been washed away) with hot water to remove caffeine, which is recovered and fetches a good price. The decaffeinated beans are then processed into roasted coffee in the usual way.

Coffee use

Coffee was once essentially a drink of the south, but a northern invasion has started. Average use of coffee in India is only 62 gms a year, just one-sixth that of tea. Since nearly twice as much coffee as tea is needed to make a cupful of beverage, the difference in brew consumption is even larger.

BEVERAGES IN NUTRITION

Tea and coffee are not considered as foods, but as refreshing

and stimulating beverages. But since it is not unusual for individuals to take even 6 cups of them every day, or about one litre, even small levels of nutrients or anti-nutrients could have significance.

In tea and coffee brews, the macronutrients, namely carbohydrates, proteins and fats, are present at very low levels, so calorie and protein contributions are negligible. Of course the addition of 25 to 50 ml of milk to a cup of tea, or 50 to 100 ml to a cup of coffee, and of perhaps 10 grams of sugar to each, will furnish corresponding increments of both energy and protein to each cup imbibed,

In the brews themselves, certain nutrients are present in micro amounts. A cup of tea carries a large number of minerals. Most of these are present in quantities that are too small to have any nutritional importance, but four are present in significant quantities. Thus one cup of tea furnishes 80 per cent of the needs of manganese, 20 to 25 per cent of that of iron and copper, and 10 per cent of the requirement of fluorine. Not much seems to be known on these lines about coffee brew.

Tannins are rather a nuisance, since they tie up certain important metals, particularly iron. A cup of tea or coffee each contains about 150 mg of tannin, but when milk is added, its proteins bind tannin and allay not merely its antinutrient qualities, but also its astringent and acidic taste in the mouth. However, when this complex reaches the stomach, it is again split up into protein and tannin, which can then exert its acidic action. This is one reason why dyspeptics are asked to avoid tea and coffee. In the intestine tannins have been demonstrated to suppress the absorption of cholesterol from foods like eggs, ghee and the fat in meat. The resulting lowered blood cholesterol levels could diminish the propensity to a heart attack.

When we think of tea or coffee, it is their stimulating action that is really of consequence, and this comes from a group of substances: caffeine, theobromine and theophylline. The quantities of these present in a 150-cc cup of tea are 50 mg, 2 to 3 mg and below 0.3 mg, while a cup of coffee also has about 50 to 80 mg of caffeine, but not the other two materials. All three act in much the same way, but caffeine is obviously the most important. A cup of tea or coffee clears the mind and abolishes a feeling of fatigue, and can stimulate certain persons even to the point of sleeplessness. It quickens one's reflexes, and can aid both mental and physical

work. All these qualities stem from caffeine, which is neither cumulative nor habit-forming and is free from after-effects. No wonder tea and coffee drinking have gained such popularity all over the world, and in less than 150 years in India.

Caffeine functions in a number of ways. It acts on the nervous system, stimulates the lungs, dilates the arteries leading to the heart, and also directly acts on the kidneys as a diuretic. Well-conducted studies on large groups of people in several countries all seem to show that there is no relation whatever between the extent of coffee drinking and heart disease, while the dilation of the blood vessels following both tea and coffee drinking ensures a desirable smooth blood flow. How much is too much? So differently are individuals affected by tea and coffee that it seems impossible to say. But dyspeptics, exceedingly nervous people and those with heart conditions are best advised to go easy even on these cups that cheer.

CHAPTER 7

Living Foods

Eggs, Fish and Meat

EGGS

Producing eggs

IN FORMER TIMES, *desi* hens kept on farms or in backyard gardens provided most of our eggs. They were fed some grains by the owner, but mostly foraged around for their own food After laying 10-12 eggs in as many days, there would be a fallow period of even longer duration when no eggs were laid, and when the birds would brood on their eggs to hatch them. The birds were small, so were the eggs and the yearly number rarely exceeded a hundred. One or two cocks were kept to fertilize the hens, and the rest were killed when young for the table.

The modern poultry industry works on a different system. Large numbers of birds, bred for high yields of eggs, are kept in enclosed coops which they never leave, food and water being provided. All cocks are sacrificed when quite young and ready for table use, and do not ever mate with the hens. The eggs are large and as many as 250-300 are laid in a year's duration, with no time off for brooding since the eggs are hatched in incubators. If the right feeds are given, the yolks do have a bright yellow colour, but they look pale if this is not specially done. Because there is no foraging, the flavour of these eggs is considered rather flat and unappetising by many people. In fact, the small *desi* eggs, which weigh about 30 grams, often sell today for the same price as the much larger 50-gram farm eggs.

How is an egg formed?

It is now commonly known that large farm eggs are unfertilised and cannot therefore be hatched to a chick. Even many vegetarians

are therefore not averse to eating them. How can an egg be produced when no mating has occurred? It is light which acts as the trigger. Either sunlight or artificial light falls on the eyes of a mature hen (actually on the retina, which is the sensitive surface at the back of the eyeball). This provokes the pituitary gland to release a hormone, which in turn stimulates one of the follicles that is present in an immature state in the ovary; after 6-8 hours, the stimulated follicle matures and is released as an ovum into the egg-laying tube. The ovum is the yolk of the future egg, and the egg itself is built up from the inside outwards. As the ovum moves slowly down the tube, it gets coated first with layers of whitish albumen or egg white, next with a thin, elastic white skin and finally with the shell material. Gradually the egg swells as water and salts enter it through the membranes, and finally the shell layer calcifies and grows hard. All this takes just one day, and every 24 hours one such unfertile egg is laid.

If a cock mates with the hen, the difference is that when the follicle is released as an ovum, it is fertile, and therefore eventually capable of hatching. There is no taste difference between fertilised and unfertilised eggs.

The price of farm eggs constantly tends to rise, because the cost of the balanced feeds, which it is necessary to provide in large amounts, is steadily going up. In sympathy, the prices of *desi* eggs also escalate !

Nutrients from an egg

Packed inside the shell of an egg are a variety of nutrients. This is hardly surprising, since a complete chick is formed in three weeks entirely from these nutrients when a fertile egg is hatched. Two large farm eggs or three small *desi* eggs weigh approximately 100 grams; 12 grams of this is shell, 30 grams yolk and 58 grams white.

The yolk or yellow is about half water, and the rest is fat and protein. The white of egg is very largely water with some proteins. Eating two eggs will furnish about 30 grams each of protein and fat. The protein is of very high quality, indeed it is the finest of all known food proteins. In rat-growth experiments in the laboratory, it stands well above all others, with a so-called protein efficiency ratio or PER of 3.9, as against 3.1 for milk proteins and 2.3 for meat proteins. The net protein utilisation or NPU, which combines

in a single index the degrees of digestibility, absorption and utilisation by the body, is 100 for egg protein against 80 for meat and 75 for milk protein.

The fat in eggs is unsaturated, and contains both linoleic acid (which is also present in unsaturated vegetable oils; see page 36) and arachidonic acid, an "animal" poly-unsaturated fatty acid not found in any common vegetable oil, and especially essential for very young, growing children. The fat moreover is in an emulsified form that is easily digested by children, adolescents and old people alike. The fat is also rich in a class of fat-related compounds called phospholipids, which help to transport the fat proper through the blood to all parts of the body for use as energy, or as an essential constituent of the structure of every cell wall.

Eggs are storehouses of vitamins: as many as 14 are present. Two eggs give one almost all the vitamin A, vitamin B 12 and folic acid that one needs, and about one-fourth of most other vitamin requirements. Eggs also contain a dozen minerals, among them calcium and phosphorus, the minerals most largely required by the body. The iron present, though not large in amount, is totally absorbed when eggs are eaten, whereas from most other foods iron absorption is usually just 5-10 per cent of what is present. Eggs also carry iodine and thus have protective value (see page 72) against goitre; the quantity in eggs can be very much raised if more iodine is added to the food given to hens. What is totally lacking in eggs is vitamin C, and to get this vitamin one has to rely on other food sources.

People prone to coronary heart disease tend to show high levels of cholesterol in their blood (over 220 mg in 100 ml against common levels of 120-160 mg). They are usually advised to reduce their consumption of eggs, since the yolks of two large eggs contain 700 mg of cholesterol. Every day however, two or three times this quantity of cholesterol is made in the body from other food breakdown products, and such synthesis is subject to feedback control: that is, if more cholesterol is eaten, less will be synthesised. Though exaggerated fears about eating eggs are probably unjustified, those prone to high blood cholesterol levels may do well to reduce consumption of egg yolks.

Eggs contain biotin, a B-group vitamin whose absence in the food of children leads to persistent diarrhoea and abnormal skin condition. Avidin, a protein present in egg white, ties up not only

this biotin, but any other quantity present in the diet, and thus deprives the body of this vitamin. When eggs are boiled, fried or otherwise cooked in any way, the avidin-biotin complex breaks up and the vitamin is released for use by the body.

Some myths and facts

Raw eggs seem to have no special virtue in nutritional terms, and even have the drawback of biotin unavailability which we have just discussed. The colour of the shell is of no consequence at all, and is simply a characteristic of each breed of hen: Rhode Island Reds give brown eggs and Leghorns white eggs, and the eggs of crows are a beautiful green colour with brown specks. The colour of the egg yolk depends on the hen's food; a deep yellow yolk could be rich in the carotene form of vitamin A, but even a light-coloured yolk can carry even more of vitamin A *per se* if the feed is designed suitably. As we have seen, the flavour of the egg depends on the feed and is of no nutritional relevance.

The percentage composition of egg contents is fairly constant. A large egg will therefore furnish more nutrients than a small one. In fact two large eggs as we have mentioned furnish the same nutrients as three small ones.

Duck's eggs are also eaten. Because ducks forage for food, their eggs tend to carry flavours and taints which may not be relished by everyone. They are very similar to hens' eggs in composition and nutritive value, and have the added advantage of being larger in size. One serious drawback to ducks' eggs is that they frequently carry dangerous salmonella organisms, and if insufficiently cooked could give rise to gastroenteritis. Hens' eggs are much less prone to carry salmonella.

During the war years, egg powder manufacture was developed to feed troops in remote and far-flung areas. Just as milk powder is obtained by removing water from milk using such processes as roller drying and spray drying (Chapter 3), the contents of eggs by similar operations yield a fluffy yellow powder. If properly made, this powder reconstitutes easily with water for use in making omelettes, cakes and ice-cream. Every 100 gms of egg powder carries as much as 43 grams of protein and 43 grams of fat, besides a three-fold concentration, broadly speaking, of the vitamins and minerals present in the whole egg. The only loss over fresh eggs will be of materials like vitamin A and thiamine that are sensitive to heat.

In terms of cost, eggs are very similar to milk or meat as providers both of total calories and of proteins. However, the egg scores even over milk in terms of its many vitamins and mineral constituents, besides being much less bulky to consume.

Eggs in practical use

Eggs are versatile cooking ingredients which can even be eaten raw (though this is not advisable for reasons connected with the availability of the vitamin biotin, as discussed on p. 108), especially after whisking up with milk. Eggs can be boiled or fried, or beaten up for use either as an omelette, or as a batter for meat chops, or in Chinese-style noodles and soups.

Beaten eggs hold a large quantity of air in the form of fine bubbles. When employed in a cake mix, these bubbles expand: the egg white protein, or albumen, gives strength to the walls of the air pockets and the resulting cake will bake to a light, porous structure. The presence of egg yolk confers stability on emulsions of oil and water, and it is therefore used in making mayonnaise (80 per cent oil, 10 per cent water and 10 per cent egg yolk), and as an ingredient of batter or dough. In ice-cream, ice-crystals are prevented from forming and growing if eggs are present, leading to a smooth, creamy mouth-feel. This is also true of whipped creams and certain Indian sweetmeats. The thickening ability of eggs is remarkable: egg white if sufficiently beaten will even stand up stiffly by itself, and whole eggs beaten with milk will set to a custard.

Egg white albumen will coagulate or set at 60–65°C, but at boiling water temperature of 100°C it becomes tough, non-elastic and rather unpalatable. When sometimes a fully-boiled egg shows a greenish tinge on the yolk, it is because the iron present in the yolk has reacted with the hydrogen sulphide evolved by overcooked protein to give green ferrous sulphide. The green tinge can be reduced by putting the hard-boiled eggs in cold water.

Except for raw eggs, there is little difference nutritionally between boiled, fried or beaten-and-cooked eggs. Lightly-boiled eggs leave the stomach in about 100 minutes, against twice this time for full-boiled eggs or an omelette. From the intestine, all forms of eggs are fully absorbed. Because they leave no residue at all in the intestine, eggs tend to be constipating to some persons. A small number of people are allergic to certain foodstuffs containing proteins, and

eggs are among these: even a very small portion will cause a violent reaction such as vomiting, swelling or skin rash. If babies show such a reaction, they should not be given eggs. For most children, eggs are an excellent food; the yolks can with advantage be introduced in very soft, mashed form at about 4 or 5 months of age, and the quantity increased to one full egg by the time the child is 7 or 8 months old.

Gastric patients find egg dishes useful, since less hydrochloric acid is secreted in the stomach than when meat or fish is eaten. Better still are egg-plus-milk combinations, such as custards. Since eggs carry no carbohydrates, but do have a variety of other nutrients, they are useful in weight-reducing diets. For young children, pregnant women and lactating mothers, who have special needs of nutrients, eggs are of particular value in India since the general diet is heavy in carbohydrate, moderate in protein of good quality, and rather poor in fat.

FISH

Big fish, little fish

With a long coastline sweeping right around the country, one might expect a lot of fish to be eaten in India. Of the 20 lakh tonnes or so caught annually, about two-thirds is sea or marine fish, which includes such varieties as the sardine, mackerel, shark, pomfret, Bombay duck (a corruption of the local name bombil) and sole. The rest consists of fresh-water types, like the rohu, catla and mrigal (all Indian types of carp), the hilsa (a herring), bhekti of the perch family, and murrel. Catfish flourish in some river estauries and reservoirs. Of this total fish catch, about two-thirds is eaten fresh or after brief residence on ice. The remainder is preserved in traditional ways by drying in the sun or over a fire, wood smoking, or canning with salt or spices.

Till very recently, hardly any transport of fish was possible. Once ice became available, even overnight movement of fish packed in ice in bamboo or wooden baskets has come to be practised. Nowadays plywood chests lined with polystyrene foam are employed and this has further enlarged the welcome use of fresh fish at the cost of cured and dried forms. There is very little canning, less than one percent of the total catch, and even this is mainly prawn, shrimp, mackerel and sardine.

What has grown is the export industry, and this is almost totally concerned with prawns and lobsters. Once these were "wet" packed in brine, but today they are simply cleaned and washed, sorted according to size, packed in polyethylene bags (all this is done in cold rooms by women under a strict hygiene regimen) and stored and transported overseas in frozen condition so that the original fresh flavour and fine texture are retained. The so-called tiger prawns are so big that just twelve of them weigh a kilogram. Something like Rs. 200 crores worth of prawns are exported every year: no wonder there is little left, and then only shrimp of the smallest sizes, for sale in the Indian market! Frozen transport within the country has been slow to develop: there are barely a score of refrigerated railcars available on wheels.

Nutrition through fish

Fish does furnish animal protein of high quality, and there is little difference in this regard between one fish and another, or between fish and shellfish (sometimes called seafood). All carry the same level of protein, 18-20 per cent, as does mutton, and at half the price. Except for the oil sardine, which has 27 per cent fat in its flesh, the herring with 12 per cent, and the hilsa with 19 per cent, most fish carry flesh with less than 2 per cent fat. Nor is there any carbohydrate at all, so that fish has its value in weight-reducing diets. Fish is a first-class protein, superior to meat and about equal to milk. This is because the level of the amino acid lysine in fish protein at about 10 per cent is exceptionally high, as is also the level of methionine at about 3 per cent. These are two of the essential amino acids that it is not easy to get in sufficient quantity by eating vegetarian foods based on cereal staples like rice and wheat. The low quality of cereal proteins can be buttressed by the large quantity of these amino acids present in the protein of fish: thus in a cereal-fish combination, the entire protein, derived from both sources, gets elevated to a higher quality.

Fish and shellfish also furnish a variety of minerals in fair amounts. These include calcium, phosphorus, magnesium, copper, manganese and zinc. Iron is particularly high in sea fish, and shellfish have about thirty times the level of freshwater fish. Goitre, caused by a deficiency of iodine, is said to be totally absent in Japan, a sea fish-eating country. Fluorine, important for good

tooth development, is also at a high level in marine fish. Shellfish carry three times as much copper and zinc as do river fish. The penchant of shellfish to concentrate metals in their livers is also true of mercury. The famous outbreak of Minamata disease in Japan, characterised by numbness of the legs and mouth leading to an unsteady gait and slurred speech, was traced to discharge of effluents carrying mercury from a factory into a sea bay from which prawns were being caught. The sodium content of fish flesh is low (40 mg 100 gm) and it can therefore be included in diets designed to control high blood pressure.

A word about fish liver oils. The body oils of fish, whether fresh or sea water, carry very little of either vitamin A (0.3 microgram or mcg per gm) or vitamin D (0.2-0.4 mcg gm). Even the liver oils of freshwater fish contain just about twice this quantity of vitamin D. But several species of sea water fish, like the cod and shark, concentrate in their liver oils large amounts of three fat-soluble vitamins. Each gram of liver oil may carry: vitamin A, upto 150 mcg, vitamin D, from 5-10 mcg, and vitamin E, from 1-2 mcg. The vitamin A derives from the prawns eaten by these fish, which get them in turn by swallowing the diatoms of the sea which are rich in carotene, the precursor of vitamin A. The vitamin D in fish oil is perhaps synthesised by the fish. Cod and shark liver oils are extracted and used as sources of these vitamins for babies, pregnant women and nursing mothers. Human needs are of the order of 750 mcg a day for vitamin A, 5 mcg for vitamin D and a much larger quantity of 25-30 milligrams for vitamin E, so even a teaspoon of shark liver oil is all that is necessary to get enough of the first two vitamins. The use of whole livers of cattle and chicken in our food is another way of ensuring not only a supply of these vitamins, but of several vitamins of the B-group as well, besides of minerals like iron.

Fish and fever

Certain individuals are born allergic to specific forms of protein-containing foods, such as eggs, meat and even milk or curds; fish also figures in this list. The usual symptoms of allergy are sneezing, swelling, rash, vomiting, diarrhoea and fever. The sequence of events is quite complex. Entry into the body of certain proteins, termed antigens, causes formation of specific countering antibodies; these are then stored for future use, and this reservoir

confers immunity. When the same antigen again enters, these antibodies are torn away from the body tissues. The almost imperceptible damage thus done to the tissues causes release of small amounts of a substance called histamine. This is carried to the skin and mucous membranes to give rise to various allergic symptoms.

Fish goes bad rather easily unless continuously kept frozen, and ingestion of spoiled fish may cause intestinal upsets. At one time this was attributed to poisoning from ptomaines, substances produced when bacteria react with decaying foods. However many putrefied foods are harmless, like Limburger or Gorgonzola cheeses for example. It is only when an infection occurs simultaneously with decay, say through staphylococcus bacteria, that toxic effects result. Smoked, salted and canned fish could all harbour various staphylococcus species that generate enterotoxins once they enter the intestine, with resulting fever. Bacterial poisoning has on occasion been specifically traced to consumption of dried Bombay duck. Fish from polluted coastal waters into which sewage is discharged could carry bacteria like salmonella and shigella which secrete toxins in the body, and could make one quite ill.

A brief precis of what happens during infection may be in order. Bacteria include species like salmonella (meat, eggs and contaminated water are likely sources), shigella (water, flies), *Vibrio cholera* (water, food) and various viruses. The latter include *Escherichia coli* which is a very common cause of gastroenteritis, since this virus is harboured in food, clothing, hands and adult human carriers, and can persist for months even in dust and on furniture. Once any of these pathogenic organisms enter the body, the latter sets to work to try and destroy the invader. Saliva, and several other body secretions, contain powerful enzymes, lysozyme for example, which do so quite effectively. The mucous membranes in nose and throat trap bacteria as they pass along. Lactoferrin, a compound present in saliva and intestinal fluid, has a greed for iron, and can destroy bacteria by depriving them of this metal. The stomach, as we know, secretes hydrochloric acid: this is so effective a killer that the organs that follow it in the digestive tract, the duodenum and the jejunum, are virtually sterile. The intestine is the body's last battleground. The many microflora living there prevent proliferation of pathogens by

competing with them, a process called bacterial antagonism. In addition, a very complex defence mechanism operates in the intestine between the cell components and the surrounding medium.

MEAT

Each to his taste

Meat eaters in India prefer goat mutton, which accounts for about 40-45 per cent of the total meat consumed. The rest is about equally divided between sheep mutton and beef, which again is derived about two-thirds from the buffalo and one-third from the cow. Pork constitutes just 5 per cent of the total meat consumed, which amounts to about five to six lakh tonnes a year. Another one and a half lakh tonnes of chicken meat is also eaten. This works out to an average of almost exactly 3 grams of meat each day for everyone. If one were to calculate for the non-vegetarian population alone, who constitute about three-quarters of the total, the figure is still just 4 grams of meat a day. Nor is this surprising, since meat is an expensive food. Even affluent families can rarely afford daily more than 50 grams for each member. The Indian Council of Medical Research prudently advocates just 30 grams of meat a day in an adult non-vegetarian balanced diet.

Meat handling and processing

Unlike in the West, a negligible proportion of meat is frozen or canned in India. Practically all of it is freshly killed and eaten. Goats are brought to the slaughter houses, certified by a veterinarian where such arrangements exist, and slaughtered either by cutting first the jugular vein below the neck and then the windpipe (called *halal*), or by decapitation in one blow (termed *jatka*). The animal is next stripped of the skin (this is done in a jiffy), slit down the front, the entrails removed and the carcass hung on hooks prior to transport in batches to the retail market. Simple but desirable provisions in the abattoirs would be a good water supply, tables of easily-washed stone (in place of wood) on which viscera can be handled, a system for disposal of the carcasses that are condemned by the inspectors for anthrax infection, disinfection of the abattoir at the end of the day, and insistence on removal of the rectum to prevent faecal contamination. It is fortunate that

tuberculosis in animals is rare in the tropics, and also that salmonella are generally found to be absent. But high coliform counts from hands, knives and animal faeces are common and could lead to outbreaks of fever. Refrigeration just at one point in the total chain is not always a blessing, since once meat leaves a cold store, it deteriorates with great rapidity.

Frozen dressed chicken is rapidly growing in popularity in urban areas because of convenience, even though the flavour, through the absence of fresh blood, and the texture, which tends to be dry, are less appealing than for a fresh bird. Because of the delicate flavour and generally high image of chicken meat, it was traditionally more expensive than mutton, but as true feeding expenses are beginning to be realised, and the returns worked out, a kilogram of chicken costs less today than does mutton.

Below the surface

An experienced housewife knows that in buying mutton she must look for a bright red colour, since old meat fades to pink or grey. The flesh must be moist, and resilient but firm. A live chicken should not be too old, the signs used being dry, scaly feet and hard flesh on the thighs. A frozen dressed chicken that weighs too much, say over one and a half kilograms, is at risk of being an older, stringy bird. When buying pork, the fat should be firm and rubbery, not flaccid.

Any tin of canned meat or fish which shows the slightest sign of bulge at the ends should of course be rejected, as should one with any trace of rust (see page 151). Meat for canning is cooked sufficiently in the factory to kill all proliferating bacteria, and salt, nitrates or nitrites are added to prevent the germination and growth of spores. Nitrates also give meat an attractive red colour. Recent studies have shown that nitrates can cause lowering of blood pressure and destruction of haemoglobin in blood, especially in children, while nitrites react with the amines present in fish, meat and cheese to give nitrosamines which are carcinogenic. There are therefore restrictions on indiscriminate use of these compounds in canned products.

Smoked foods like meat and fish are becoming suspect despite a long history of usage. Dwellers in Iceland, where fresh meat is scarce, consume fairly large quantities of smoked meat, sausages and fish, and also show rather a high incidence of stomach cancer.

Meat cooked on the direct flames of a fire, as could happen in barbecuing or roasting, can easily char, and both charred meat and charcoal smoke have been shown to carry carcinogens. When roasting skewered kababs it is advisable to keep them out of contact with glowing coals or with flames.

Looking ahead

We have in the country about 3000 municipal abattoirs which handle just 12 per cent of all animal slaughter. The rest is simply unsupervised killing. Nor are the slaughter houses themselves by any means ideal: both quality and number need to go up.

Use of pork needs to be given more attention in future. Pigs are the main means through which meat production is being raised in China, since these animals feed on all sorts of wastes—farm, garbage and even sewage wastes. Dangers of worm (trypanosome) infection are overcome by immunisation introduced through the non-forage feed.

Poultry development in India has followed the path of large farms intensively raising flocks of pedigreed birds. Such farms require a huge capital outlay, and there is a good case to consider decentralised egg and poultry production by small rural farmers each owning a few birds, followed by modern systems for collection, refrigeration, processing, transport and distribution, a pattern which has been successfully followed for milk development. Poultry are the least expensive of animal foods to raise. A bird given 50 kg of feed a year yields in return 200 eggs, 1.5 kg of meat and 25 kg of excreta of high fertilising quality.

Unlike growing animals, fish-raising requires no direct provision of food, but ponds do require plant nutrients to encourage the growth of vegetation that will support abundant fish life. The potential for fish, both from the sea and from inland lakes, ponds and rivers, is many times the present yearly usage of about 10 lakh tonnes of each kind. Transport and marketing are important ancillaries to such development.

CHAPTER 8

Hot from the Oven

Bread, Biscuits and Cakes

What goes into bread

We saw in Chapter 1 that wheats could be hard, medium and soft, that the sticky protein gluten played a major part in this classification, and that each baked product required a special type of flour. For making bread, hard flours of high gluten content are called for, and the dough should have a high degree of development but not too much extensibility. This is particularly true when bread has to be made in large factories, because of the extensive handling that is called for in mechanised production. When made at home, or in a family-style bakery, even soft flours of low gluten content can yield excellent bread if the dough is hand-mixed, the fermentation achieved not with yeast but using chemicals, and the baking procedure carefully watched and controlled.

In practice a good wheat flour will be creamy rather than dead white in colour, and dry to the touch. It will not lump together when squeezed between thumb and finger and will easily dust off from a sheet. A flour must also smell fresh and sweet; this is easier to detect if the flour is shaken with some hot water and the vapour is sniffed. As a rough guide, 100g of good flour will give 350g of bread.

In making bread, the flour is mixed with water in the correct proportion. The gluten builds up an elastic network, which after baking will hold gas and set to a firm but springy texture. Several other ingredients are added during mixing. A little salt adds taste, controls the activity of yeast, and improves dough handling and stability. Sugar too adds taste, but has a more important function as a fermentation medium for the baker's yeast that is added. Yeast is really a kind of fungus that multiplies a million times in 10 hours; in doing so it feeds on sugar and converts it into alcohol.

carbon dioxide gas and water, besides small amounts of a number of flavour materials. Special strains of yeast are selected for baking on the one hand and for brewing alcohol on the other, as we shall see in Chapter 12. The release of carbon dioxide is what gives bread its spongy structure. Also added during mixing are special plastic bakery fats (see page 39), which contribute to the texture of bread (and even more so of biscuits); the air or gas trapped in the fat particles enable them to grow larger in size till they finally escape during baking, while fat also coats the particles of flour and prevents them from clumping together.

Several other materials in small amounts are added to bread dough during mixing. Chemical agents were once used to bleach and whiten the bread, but today a common product for this purpose is whole soyabean flour, which carries a natural oxidising enzyme. Wheat flour itself contains two amylase enzymes, alpha and beta. Both break down starch to sugar, but the beta form, which is present in abundance, is unable to attack starch granules that are not damaged, and attacks even damaged starch granules rather slowly to convert them to the sugar maltose. Alpha-amylase is much more aggressive in its attack on damaged starch grains, turning them into smaller units called dextrins; this enzyme is present in only small amounts in wheat, and it is common to add extra enzyme to the flour when it is kneaded. This used to be called diastatic enzyme and in traditional practice, sprouted barley, or even sprouted wheat flour itself, was used for this purpose, but today stronger enzymes isolated from certain fungi are preferred. Such enzymes ensure that enough sugar is generated for fermentation (especially when no extra sugar is used) that will cause the release of carbon dioxide gas. To give softness or pliability to bread, an emulsifier is used; commonly these are the monoglycerides of fatty acids, for example GMS or glycerol monostearate (p. 48), which can be visualised as triglycerides (all fats are essentially triglycerides, as picturised on page 31) in which two of the three fatty acids have been removed. Yet another chemical additive employed in tiny quantities is potassium bromate; this is termed a flour improver, and it functions by causing additional cross-links between gluten molecules with consequent benefit to the mechanical properties of the dough; however, it is recognised that not all flours are capable of improvement by such addition.

Baking bread

The blending of flour with water and all the additives needed is not simply a mixing operation. It must be so carried out that lots of air is trapped in the mass to act as the nucleus for carbon dioxide evolution, and time must be allowed for the full development of the gluten network and for the products of enzyme action to mellow and ripen the dough. In mass-production of bread, there are two ways of achieving all this. In small bakeries, the entire mass of the dough with a rather high amount of added yeast is mixed and thumped in special machines (much as is done by hand in making chapatis), after which the dough is left to ferment or ripen for 2 to 4 hours. In the other process, used by our large bakeries, only a small part of the dough is mixed with yeast and the additives, and the mass is rapidly mixed for about 10 minutes. This so-called sponge, which is quite thin in consistency, is then uniformly blended with the bulk of the dough. The mass is then rested for a period of 2.5 to 3 hours while fermentation progresses and the gluten network develops. This is followed by a so-called knock-back mixing, when the ends of the dough are turned inwards so that accumulated gases are removed, the dough comes in contact with fresh oxygen, and yeast can once again resume its function.

The next step is to cut the large mass of dough into pieces, each of which will become a 400-gram loaf of bread, and this is done in a dough divider. The cut pieces are irregular in shape and have sticky surfaces, so they go to a rounder which closes these surfaces by rolling them around the surface of a drum while dusting them with flour, much as is done in making a ball of chapati dough by hand. This operation may seem trivial, but what it does is important for later crust formation: the surface is dried both by the flour coating and by exposure to air, and the cells of carbon dioxide on the surface collapse and a thick dough layer is formed. The rounds of dough now pass slowly taking about 10 minutes through an unheated but very humid tunnel called a "proofer" where it "relaxes" and where the fermentation process goes a part of the way. At the end of the proofing tunnel, the pieces of dough, each in the form of a flattened ball, pass to what is called a moulder, where they each get flattened into a sheet by passing through a series of rolls placed increasingly closer to each other, during which accumulated gases in the dough are expelled.

Each sheet is finally rolled up into a loose cylinder, which is again compressed in stages as it passes along the unit to give a mass of worked dough that falls into a metal mould called a pan. Here it is left at a high humidity for an hour for a second "proofing."

Baking is effected by passing the pans slowly along a belt through an oven which is set at about 260°C for some 30 minutes, when the dough "springs" into shape. Many interesting changes take place. At the high temperature water is of course driven off, and the crumb will have none at all on emerging, though it may pick up some moisture later from the atmosphere and by redistribution within the loaf. The dark colour of the crust and its taste are a result both of Maillard browning reactions (see page 13) between proteins and sugars, and of simple caramelisation of sugar. Crust flavour arises from secondary reactions, and the aromas diffuse into the body of the bread. Crust lustre is believed to be imparted by dextrins, which are partially-hydrolysed sugars, while its rubbery rather than crisp texture is attributed to the fact that there is not enough water to hydrate the starch.

Inside the loaf too, many things happen in the oven. Very quickly yeasts and bacteria are killed. Next, as the temperature inside the mass rises, starch gelatinises, protein coagulates and enzymes are deactivated. The hydrated gluten sets to a firm structure which holds the starch. The carbon dioxide and other gases formed escape, swelling out the bread and leaving holes in the mass. In the final stages, when the temperature within the bread approaches 100°C, a good part (but not all) of the water escapes, and the bread actually shrinks slightly in volume. In fact good bread has upto 38 per cent water. In the final step the bread is cooled for a couple of hours, sliced, wrapped, and sealed in waxed paper, to prevent moisture drying out and to guard against unhygienic handling. Once opened, a loaf of bread to retain its moistness is best kept even in the refrigerator in an air-tight tin or a plastic bag twisted tight.

A good bread must have volume and shape, and a crust that is pliable and not too dark in colour. It must be moist, and have an elastic and even texture with no gaping holes, with a characteristic sheen or sparkle on the inner skins. The flavour must be fresh, with no taint either of sourness, staleness or ropiness, which is a rotting, sickly-sweet smell caused by bacteria. Neither white, black or green moulds should be present. Faults of this kind are

often caused by uncleanliness in the bakery.

Buns and naan

Buns are made very much like bread, but employ a much finer soft flour of high absorptive capacity, more water, upto 10 per cent sugar (and even more for a sweet roll), say about 5 per cent of milk, and a similar quantity of fat. Usually also twice as much yeast is used as in making bread, and all this gives the bun a sweetish, chewy quality and a more plastic crust. Once the dough has been mixed, it is divided, rounded, proofed, formed and baked in individual pans much as is done for bread.

The Indian roti, naan, resembles a bun but the texture is less plastic. Commonly the product is made from maida laced with some sugar, salt and fat, and leavened with yeast or curds or both. The soft dough is fermented for an hour under cover of a damp cloth, divided into balls that are again rested, patted to a heart-like shape and baked after slapping them on the walls of a hot tandoor or oven. Attempts to produce naan as a unit item in a large modern bakery yielded a rather dry crumbly product which staled rapidly, but there is no reason why naan should not be mass-produced successfully if hand-making details are properly simulated on machines.

Biscuits

As we have seen in Chapter 1, biscuits require a soft flour that will yield a dough which has poor elasticity or resistance, but is extremely extensible. A strong gluten would prevent the dough from spreading, and therefore hamper the moulding of biscuits to specific shapes. Wafers use exceptionally soft wheats, or wheats artificially weakened by the addition of cornflour, arrowroot or potato flour. Dry crackers can take slightly harder wheats. Biscuit flours must have only a low capacity to absorb water, and therefore damaged starch grains must be minimised through careful grinding of the wheat grain. Colour must be white rather than creamy, and the flour must be fine and soft and fresh, giving neither a musty nor rancid flavour when shaken with hot water and sniffed.

The equipment to make biscuits consists of an efficient mixer for the dough, which is then transferred via a hopper to rollers that convert the mass into a sheet of dough which must be

uniform both along and across the sheet. The sheet is folded over once or more after dusting, and again rolled: for example in making cream crackers a layery texture is expected. The shapes are then either cut out from the sheet using a revolving stamping machine, which is the practice for Marie biscuits or cream crackers, or shaped from the dough in a suitable mould, as is done for the soft doughs used in making gingernuts. Another technique, used in making wafers with their sharp edges, is to cut a ribbon of the dough as it passes along a delivery chute into pieces of the right size. However made, the shaped dough pieces resting on a band made of steel or woven wire, pass into a tunnel-like oven kept at temperatures ranging from 200 to 300° C for varying lengths of time, from say 5 to 10 minutes, followed by slow cooling as they pass in continuation through an unheated tunnel, after which they are packed. The changes in biscuits during baking follow the same sequence as those described in baking bread: solubilisation and melting of the components during the early stage, accompanied also by gas evolution; at mid-stage, protein coagulation, starch gelatinisation and escape of moisture; and in the end, the final shaping of the biscuit and mild surface browning.

Five representative biscuits will now be described.

The common *Marie* is technically a semi-sweet, hard-dough biscuit which uses already soft flours further weakened say with cornflour, a low fat content of below 22 per cent, and a sugar content of 24 per cent, while the rather bland flavour stems from milk, sugar syrup and vanilla. Dough mixing is prolonged to fully develop the gluten first (usually some baking soda is also added) and then to break it down to give the biscuit its final tender, brittle texture. The dough is folded over but not dusted with flour while mixing. Arrowroot biscuits are very similar, using arrowroot flour for weakening, less fat and sugar, and a very thin dough.

Cream crackers are also hard-dough biscuits, but the dough is fermented using yeast for as long as 3 hours, and the dough is folded over many times, dusting each time with a flour-fat mixture. *Cheese crackers* are made the same way and dusted lightly with salt before baking. *Salted snacks* are again similar but are sprayed with oil after baking and therefore go rancid faster than do other biscuits.

Gingernuts are traditionally hard and brittle, ginger biscuits

slightly less so. The hardness is obtained by using a high content of sugar and sugar syrups, and the dark brown colour by prolonged baking in a comparatively cool oven. The cracks in these biscuits are achieved by allowing the dough to flow, softening the gluten with sugar and soda, and using large sugar crystals to create the crack.

The familiar *glucose* biscuits contain added glucose, and a little more glucose arises by the inversion of sugar to glucose and fructose through enzyme agency. The final biscuit will carry about 2 per cent of glucose, and about 30 per cent of sugar. Since sugar is high, fat is kept low, and it is usual to shape the dough into a biscuit on a rotary moulder, which is a metal block carrying depressed biscuit shapes into which the dough is forced. The moulded pieces are deposited on a rubber-covered moving belt which carries them into the oven. Many so-called soft dough biscuits are made in this way.

Wafers need, not a soft flour like other biscuits, but one of medium strength, usually achieved by blending a soft flour with a strong one. Apart from a little skim milk powder, salt and sugar for taste, and small quantities of fat and baking soda, hardly anything else is added. The porous friable structure develops when the batter suddenly encounters a very hot metal plate, and steam is suddenly generated and escapes. Cream fillings for wafers are the usual mix of 60 parts icing sugar and 40 parts fat.

Cakes

Flours of the lowest gluten content are well suited for cakes, and will have low viscosities. Water-absorption must be really low, so starch damage has also to be minimal, and this means gentle but very fine grinding. A white colour and sweet taste and smell are important. A good cake flour, in contrast to a bread flour, will form a stable lump when squeezed between thumb and fingers, and will not easily dust off from a sheet.

The fat is of special importance in making good cakes. Usually hydrogenated fats of a special kind are used : what is important is that they must be of a creamy consistency, and so made that a lot of air (or sometimes nitrogen to improve the keeping quality of the fat) is held trapped and the fat particles are themselves very fine. In baking, the gas in the fat globules expands and escapes to give the cake a light, fluffy texture. Fat also coats the flour

particles and prevents them from forming tough gluten networks, contributing again to lightness in the cake.

Sponge cakes employ as much sugar as flour, and as much as 70 per cent of a creamy fat. The fat and sugar are creamed together, sometimes with an added emulsifier; eggs are whipped separately, and then the two are blended. Next, flour with added baking powder in comparatively large quantity is added with gentle mixing to the fat-sugar-egg blend along with water to yield a soft, light consistency. The sponge is baked in greased and dusted moulds at 190°C for 25 minutes, and removed while still hot. *Swiss roll* is similar, and use of even more eggs than in sponge cakes accounts for its yellow colour.

Pastry

Let us consider two kinds of pastry. A *patty* is a many-layered product with alternating sheets of very thin dough and of creamy fat which makes up 60 per cent of the product. Only a part of the fat is used initially in kneading the flour, which is rested for 10 minutes under a moist cloth and then rolled into a sheet. The sheet is divided lengthwise into three portions, the outer two being brushed with fat and then folded inwards, followed by rolling flat again. This is done several times, with a short rest between rollings, after which the sheet is cut into rectangles for baking. In the oven, the moisture present expands during early baking, gets trapped in the fat-dough layers, and causes them to separate and pile up. At a later stage of baking the dough structure sets and the layers become stiff and crisp. Patty fillings can consist of cooked vegetable, meat or chicken, or jam.

The pie crusts that are used to hold fillings of fruit (apple, pineapple, jam), meringue and so on are called *short-crust pastry*. These crusts have to be tender in structure, but hard and strong. They are essentially mixtures of hard flour, half its weight of fat, eggs, sugar and a minimum of cold water; there is hardly any mixing before baking, since mixing will toughen the gluten to yield an even tougher crust. *Tarts* and *fruit pies* are immensely popular elsewhere.

Nutrient losses in baking

In Chapter 1, the levels of vitamins and minerals in wheat and its products were outlined, and the fortification of flour or resultant

atta with nutrients was mentioned. In the USA, the nutrient levels required in flour as well as in the bread made from it are specified, from which it would appear that about two-thirds or so of the flour vitamins still remain in bread after the baking process. In biscuits, practically everything is lost. Of course in both, calcium and iron remain. A slice of toast or plain cake, or two slices of bread, or a cup of cornflakes, will each weigh close to 25 grams, and will furnish 100 calories, 2g protein, 5mg calcium and 0.3mg iron, besides some 50 micrograms of thiamine, a similar quantity of riboflavin and 500 micrograms of niacin.

Protein quality however does suffer rather badly during baking, especially if reducing sugars like glucose or invert sugar mixture (from sucrose) are present. This happens through binding of these sugars with lysine, an important amino acid present in protein. Lysine has a dangling reactive amino group: a Maillard reaction occurs between this and sugar, and overall protein quality drops badly. Thus the quality of the protein in a glucose biscuit is barely half of that in wheat flour or in a chapati.

CHAPTER 9

Indian Relish

Pickles, Chutneys, Sauces and Papads

Stopping the rot

EVERYONE KNOWS HOW quickly and easily vegetables and fruits go bad. Put aside a brinjal or tomato or mango for a few days and it becomes squashy and smells rotten. Putrefactive bacteria and moulds thrive in raw products containing a lot of water (most fruits and vegetables consist of 80 per cent water or more) and some protein and sugars that can ferment, and that are not too acidic. Yeasts can flourish even under acidic conditions, which is why oil pickles sometimes develop a surface growth, especially when they go dry, and begin to smell alcoholic.

Various forms of preservation seek to overcome these drawbacks. Simply washing fruits and vegetables takes away their surface load of bacteria. Salt draws out water from the vegetable cells by a process called osmosis, and itself enters the cells; here it suppresses those bacteria which, when they grow, generate enzymes that break down cell walls, leading to softening and spoilage. At the same time, if the salt level is allowed to build up gradually, certain bacteria can grow which generate lactic acid; the latter is a good preservative and after a certain amount has been built up, the bacteria can survive no more and die out. Heating for some time is of course an excellent killer of spoilage organisms; in fact the only bacteria which survive heating are those which rest in the form of spores. Bacteria cannot also grow when there is a really high concentration of sugar. Vinegar is another preservative; it is 4 to 5 per cent acetic acid, and will by itself preserve vegetables that have been dried and salted, and even more usefully when

sugar is also present, a three-fold protective action. Many spices that impart taste to pickles also prevent bacterial growth, while also acting as antioxidants to preserve any oil that is present from going rancid.

A few simple principles operate. In plain salt pickles, at least a 12 per cent concentration of salt in any water that remains is necessary for preservation. Salt-and-oil pickles also need the same level (always reckoned on the water present); the oil functions only by coating the vegetable pieces and thus preventing air from having access to and then spoiling them, what scientists call an anaerobic or no-air condition. In vinegar pickles and chutneys, again the level of water decides how much acetic acid is necessary for preservation; it works out to 3.6 times the water present divided by 100. Various organic acids present in pickled materials, such as citric and malic acids in raw mango, citric acid in lime, and ascorbic acid in amla contribute to the acid level. In sauerkraut, the European sour delicacy, shredded cabbage is fermented for 3 to 6 weeks after adding exactly 2¼ per cent salt; this with the water present gives a 10 per cent brine solution, which permits lactic acid organisms to grow. By the time more salt is added to raise the concentration to 15 per cent, all undesirable organisms have been destroyed, and other favourable ones capable of growing under acidic conditions finish the fermentation.

Sugar alone, to act as a preservative, must be present at a very high level of 68.5 per cent. If salt or vinegar or both are present, this quantity can be brought down; thus if 4 to 6 per cent of salt is present (as is usual) and 1.5 per cent of acetic acid, even 30 to 40 per cent sugar will provide protection from spoilage. Spices like turmeric powder, mustard seeds or oil, ginger and garlic, apart from contributing flavour, help to reduce even by half the quantity of salt needed for preservation, thus permitting also a less salty taste.

Three chemical preservatives are commonly employed in preserved foods. The first is sulphur dioxide, and fruits especially are frequently exposed to burning sulphur in a closed chamber. In pickles, potassium metabisulphite or KMS is used for convenience, and the acid condition releases sulphur dioxide which is particularly toxic to mould spores and vinegar-producing bacteria. Benzoic acid is particularly toxic to yeasts, but being rather

insoluble, is used as its soluble salt sodium benzoate in jams, squashes and other sweet products. Sorbic acid, also used as its sodium salt, suppresses mould growth especially in packaged cheese, meat and fermented foods. Very small quantities of 50 to 200 parts per million of these chemicals act powerfully to prevent the growth of yeasts and moulds.

Preservation in practice

Let us next see how these general principles are reflected in actual recipes for four pickles and a murabba shown in Table 9.1. In the lime-in-salt pickle, once surface bacteria have been washed away, water is drawn out by osmotic displacement. Salt enters the fruits in sufficient quantity to act as a preservative without the development of any fermentation acids. The lime gets tenderised in texture and translucent in appearance. The same principle is used with small silver-skin onions, which are placed in a 12.5 per cent salt solution for a day, transferred to a similar fresh salt solution for another day, and thereafter arranged in a glass bottle and covered with cold vinegar; usually the vinegar has been appropriately spiced beforehand by steeping in it for several days such materials as dry red chillies, peppercorns, cloves, cardamom, cinnamon, ginger and garlic, or sprigs of green herbs like parsley, coriander, bay leaves and so on. Onions thus pickled will keep for 6 to 8 months. In Western cultures, such salt-dehydrated, vinegar-steeped materials are termed pickles, but in India the word pickle, achar in the north and uruga in the south, has a different connotation which implies the use of chillies.

This is well-exemplified in the second example of an avakkai mango pickle from Andhra Pradesh. Here sun drying, a ready facility in most of India, is used instead of salt osmosis to reduce moisture. Heavy spicing reduces the quantity of salt required, and the sesame (til, gingelly) oil used is known for its excellent keeping qualities, which the spices even further extend. In northern and eastern India, mustard oil, which is likewise stable and has a piquant pungency, is preferred for making oil pickles that are termed kassondi. Maturing for a few weeks markedly improves taste. Straight oil pickles are the commonest type in India, and a vast number of vegetables and fruits, besides meats and fish, are preserved in this way for periods of even one year.

TABLE 9.1

Some Typical Pickles and a Murabba

1. **Lime pickle in salt**

Fully-ripe limes 50
Salt, powdered 500g

a. Thoroughly wash the limes, and dry with cloth
b. Divide each lime into quarters
c. Add salt, mix thoroughly by hand, and place on a perforated tray (since juice will ooze out in plenty for 3 days)
d. Discard the juice. Place the pieces on an absorbent cloth and dry well in the sun
e. Store in a glass or glazed jar; should keep for 2 months, but could mould even earlier.

2. **Avakkai mango pickle in oil**

Mangoes (raw, medium-size, very sour, fibrous variety) 25
Chilly powder 750g
Salt 750g
Mustard seeds 450g
Turmeric powder 200g
Jeera (cumin seeds) 100g
Raw methi (fenugreek) seeds 40g
Bengal gram 100g
Sesame (til) oil 900cc

a. Wash mangoes well, wipe dry with cloth. Halve lengthwise including the stones. Cut each into 12 to 15 bits, retaining the stones. Spread out in the sun to dry completely for 2 hrs
b. Dry mustard seeds in the sun, pound to powder
c. Mix together all the solid ingredients, then grind into a smooth paste with oil
d. Coat the mango pieces with the paste, a few at a time, and put into a dry glass jar. Pour in enough oil to give a one-centimetre (half-inch) layer on top
e. Tie a clean cloth over the top, set aside. After 3 days, turn the contents. Repeat this 3 or 4 times
f. Remove small quantities for use.

3. **Brinjal vinegar pickle**

Brinjals 1500g
Mustard oil 500cc
Methi (fenugreek) 20g
Jeera (cumin seeds) 10g
Mustard seeds 20g

a. Quarter each brinjal but do not detach
b. Heat oil in a pan, add methi, jeera, mustard seeds and curry leaves and dry. Then add ground garlic and when it turns brown

Curry leaves 6
Garlic (ground) 100g
Green ginger (ground) 100g
Turmeric powder 30g
Chilly powder 60g
Vinegar 1000cc
Salt 30g
Green ginger, finely sliced 15g
Green chillies, slit 50g

add green ginger, turmeric powder and chilly powder and heat for 3 minutes

c. Add vinegar and salt, and mix everything well

d. Next add brinjals, sliced ginger and green chillies, and heat with stirring for 20 minutes

e. Cool and bottle.

4. **Mango choonda**

Raw mangoes 1000g
Turmeric powder 50g
Salt to taste
Sugar 500g
Jeera (cumin seeds, ground) 20g
Chilly powder 20g
Raisins Optional
Almond shreds Optional
Sodium metabisulphite 80 mgms or 1/50 of a teaspoon

a. Peel mangoes, cut into long strips

b. Mix the strips with salt and turmeric, set aside overnight. Squeeze out water

c. Dissolve sugar in 3 cups water, stir over a low fire to single-thread consistency

d. Put in mangoes and cook till soft

e. Add jeera and chilly powder, and salt to taste. Remove from fire, add sodium benzoate and mix thoroughly

f. Bottle and cool; will keep for 9 months.

5. **Amla murabba**

Amla (nellikai) 1000g
Alum 1g
Sugar 2000g
Saffron essence A few drops (optional)

a. Poke each amla berry all over with a sharp thick needle

b. Dissolve alum in water and soak the fruits for an hour. Drain fruits and wash with water

c. Boil the fruits in water till soft, cool, drain water

d. Dissolve sugar in one litre water, cook over low heat to give a strong, two-thread syrup

e. Put in the fruits, thicken over a slow fire to a two-thread syrup

f. Cool, add essence, bottle; will keep for 6 months.

No heating at all is involved in making the avakkai mango pickle, but the next recipe for a brinjal vinegar pickle involves cooking the ingredients rather thoroughly to achieve sterility; also, the use of rather a lot of vinegar brings down the salt content to just a taste level rather than a preservative one. Just 5cc of acetic acid if available can with advantage substitute for the 100cc of vinegar employed in the recipe.

In the next recipe, for a mango choonda from Gujarat, sugar enters the picture. Also, the mango strips are dehydrated overnight using solid salt (and turmeric) and the water squeezed out. This is a very common salting procedure in India, the salted material being employed as a relish either as such, or after further finishing as in the present instance. The sugar level in a choonda is moderate but thoroughly permeates the fruit during boiling down. Other materials which lend themselves to choonda preparation are sweet limes, all citrus rinds and amla.

The last recipe is for a murabba, an Arabic term meaning preserved or dehydrated, and here sugar in high concentration is the only preservative. Alum is injected into the fruit both to keep it firm and as a preservative, and water present in the fresh fruit is drawn out by the sugar syrup and later boiled away during thickening. At one time honey was used for this purpose, but this is expensive. Fresh amla fruit is one of the richest known sources of vitamin C or ascorbic acid, with 750mg in 100g of the fruit. The murabba retains two-thirds of this, and simple salting of amla, as described in the first lime recipe, also retains half the vitamin, with little further loss on storage of both products. These preserved products are thus of excellent nutritive value as a substitute for fresh fruits containing vitamin C. A ginger murabba is believed to relieve gas-formation and chest congestion, besides being a delicious relish. Many other firm materials lend themselves to the preparation of murabbas: semi-ripe papaya, jackfruit, ripe ash gourd and pumpkin, beetroots, carrots, dates and raisins. In fact these products are very close in type to the fruit preserves that we will consider in the next Chapter.

Chutneys

Though the word itself is derived from the Hindi chatni, here again there is an Indian-elsewhere difference. An English writer waxes

eloquent: "Chutney, he says, is a relish that is hot, spicy, sweet, sour; firmer than a jelly, less sour than a pickle, not as sweet as a jam; hot and peppery with ginger as a necessary ingredient, going deliciously with both bland and curried foods." In fact the chutney which the colonial grew to relish in India and carried back with him is nothing more than a sweeter choonda, with about twice the quantity of sugar in the recipe, and added raisins, apricots, candied peel and currants. Bottled chutneys of this description are also now made and marketed in India.

To most of us, chutney connotes a freshly-ground product made at home and eaten fresh. Coconut chutney goes with idli and dosai, and a sesame product with wheat or rice chapati. Raitas and pachadis with a base of curds are an inevitable accompaniment to a vegetable or meat biriyani. Kochumber is a blend of chopped raw ingredients, an Indian salad. Such relishes are made from a variety of ingredients like garlic, ginger, mint, cucumber, green mango, sprouted and soaked dhals, various nuts, dates and raisins. These have not yet been commercialised to qualify as processed foods.

Large-scale production

Commercial production is essentially an upscaling of home practice, with some adaptations of scale. Let us choose a sweet mango chutney as an example. The fully-grown but raw fruits are washed in a stream of running water, hand-peeled, sliced, and the stones removed. For very large quantities, machines for peeling and slicing may be used. The pieces are steeped in a wooden barrel in a 10 per cent salt solution containing 325 ppm of KMS or sodium metabisulphite (equivalent to 200 ppm of sulphur dioxide) for one day. The brine is then drained and replaced with fresh 5 per cent brine with the same KMS level. When this is drained a day later, the brined slices can be put away for 4 to 6 months, so that even a seasonal fruit like the mango is available for preserving round the year.

When needed, they are removed from the barrels, soaked in water for a few hours for desalting, then resoaked in dilute acetic acid for a few hours and drained. The pieces and added spices are boiled down in sugar solution, after which the vinegar or acetic acid is added and cooking continued for a few minutes. The

product is matured in barrels, and the acidity and sugar content adjusted before bottling. This is done cold into clean, absolutely dry bottles that are filled to the top. Screw-on metal caps must be heavily coated with a suitable enamel or lacquer that withstands corrosion. The cork circle below the lid carries tannin which will react with iron in the pickle to give a black colour, and a thin circle of plastic below the cork, or even a plastic screw cap itself, is in common usage today.

Highly-acid pickles in bottles are not usually sterilised after packaging but if the acetic acid level is below one per cent, the bottles are filled and capped hot to exclude air, and sterilised in lots with boiling water under slight pressure. Luckily most pickles do not easily get reinfected with spoilage microbes after the bottle is opened in the home. Incomplete brine curing of the mango slices may leave live yeasts, which are more difficult to kill than bacteria, and these may later ferment in the bottle. Fermentation may also occur if the acetic acid concentration in the liquid portion is below 3.6 per cent. Once these start, nothing much can be done except to throw the pickle away. The same is true if yeasts start growing as a cream-coloured layer, frequently on the surface of protruding pieces. Moulds rarely grow on pickles.

Vegetables in tins and packets

Processing of peas will serve to illustrate how a seasonal food material can be stretched for use all the year round and in a variety of forms. Peas are deshelled and pricked with a sharp stainless steel pin (an iron pin could lead to blackening later). The peas are taken in a muslin bag and immersed for 3 to 4 minutes in boiling water containing three salts. One is 0.5 per cent potassium bisulphite, the preservative, the second is 0.1 per cent magnesium oxide which keeps the peas firm after canning, and the third is 0.1 per cent sodium bicarbonate which helps to retain an attractive green colour. The blanching operation itself has several purposes. For one thing the peas are cleaned of surface slime. The taste improves through removal of certain acrid and astringent principles from the skin, while its loosening and toughening lead to compact packing later in the can. Enzymes that cause spoilage and discolouration are destroyed and gases like oxygen are expelled. The

blanched peas are quickly cooled by dipping in cold water. They can then be further preserved in at least four ways.

Firstly the peas can be put in cans, which are then almost filled with a 2 per cent brine solution which also carries 4 per cent sugar for purposes of taste and sometimes a little mint flavour. The lid is then partly sealed-on or clinched. The cans are placed in boiling water, or exposed to steam, till the centre of the can reaches 82°C, the temperature needed to exhaust the contents of all the air present. This is an important concept, and the bigger the size of the tin, the longer will be the time for exhaustion since water and salt solutions conduct heat slowly, and sugar syrups very slowly indeed. Heat exhaustion has several benefits. Oxidation of vitamin C by air is lessened, the corrosion and discolouration of the can during later storage is prevented, and the peas swell to their final size and can be filled compactly into the can. Finally the vacuum that is created when the lid is sealed on, either by means of a hand operation, or automatically using a special seamer, will keep the ends of the tin concave and prevent early bulging. In modern can sealing, the ends of the can are first bent over outwards to form a lip; the lid is bent over downwards and upwards to engage this lip, and the union is pressed together to give an airtight seal. Thereafter the sealed cans are pasteurised at a fairly high temperature and for a long period to destroy any living organisms left.

As a second alternative, blanched peas can be curried, along with other vegetables if desired; the vegetables are placed in a can, the hot curry made separately is poured in, and the cans are exhausted, sealed and pasteurised.

Thirdly, to make dried or dehydrated peas, the blanched peas are exposed to a slow current of warm air (the centres dry very slowly) till the moisture level drops to 4 per cent and some 400 ppm of sulphur dioxide remain left in as a preservative. The dried peas are packaged in flexible packs consisting of sheets of polyethylene, paper and almunium foil laminated together, which provide an effective barrier against the entry of air and moisture.

Finally, blanched peas may also be turned into wet and dry soups. A cream of green peas soup contains wheat flour, milk and butter besides spices, salt and sugar; it is made as in the home and canned in a well-lacqered can (the sulphur present in many

vegetables is a potent darkening agent of iron). Sterilisation is exceptionally long, since the product is of low acidity and therefore liable to easy spoilage; cans carrying more acidic products like pickles and curries are pasteurised for a shorter period, and at a lower temperature, to destroy spores present. To obtain a dry soup powder, blanched peas are dehydrated as described, and ground with the necessary spices, salt and sugar in a pre-cooked, gelatinised starch base to facilitate reconstitution of the powder in hot water.

Two modern Indian convenience foods seek to simplify use of tamarind fruit pulp. Tamarind concentrate is a water-extract reduced under vacuum to a viscous black liquid that retains all the tartaric acidity of fresh tamarind as well as its flavour, while keeping easily for a year. In tamarind powder, the souring acid has been absorbed on a dry starchy base for ease of use.

Vinegar

Though not a native product, vinegar today is made in the country and fairly widely used in pickling and cooking. Sugar by suitable fermentation gives alcohol; alcohol, when fermented by an appropriate yeast, will yield acetic acid. Vinegar is essentially a solution of 4 to 5 parts of acetic acid in a hundred of water. In fact synthetic vinegar is made by just such dilution, adding a little caramel or burnt sugar to impart colour and barley malt for flavour. A wide variety of sugar materials are fermented in India to alcohol and thence to vinegar: germinated barley to malted vinegar, wastes from the canning of fruits like the pineapple, orange and grape, tapioca, coconut, sugarcane juice, molasses, jaggery, and palm toddy. Cider vinegar is derived from apple juice. Vinegar of mellow flavour for table use is made by a slow, 'holding' process of fermentation that takes 3 months. A faster 'trickle' method employs extra air to hasten the process, but the vinegar has to be stored for 6 months so that its harsh taste and smell are mellowed by the formation of small amounts of chemicals with fruity flavours. Usually the vinegar is filtered to give it a sparkle, and pasteurised either before or after bottling to render it sterile. Only one-quarter of Indian-made vinegar is the fermented product; the rest is synthetic, an acidic material without delicate flavour overtones.

Sauces

Tomato ketchup, chilly sauce, Worcester (or 8-in-1) sauce and soyabean sauce are exotics that are finding a place on the Indian table.

Ketchup and chilly sauce are similar products, with much more chillies in the latter. Deskinned, deseeded and strained tomato pulp is boiled down with salt and vinegar, sieved through coarse muslin (use of an iron wire sieve will blacken the product) and then heated with sugar till it thickens. Sugar is employed for taste, and the main preservative is acetic acid. Spices like onion, garlic, pepper, cloves, cinnamon, jeera, paprika and ginger are earlier extracted into the vinegar that is used in the formulation. The finished products, whose consistency is important, are filled to the top in bottles and sterilised. Use of old corks on the bottles will lead to the formation of a black ring through reactions involving the tannins present in them, so either new corks thoroughly boiled in water must be used, or new crown caps with a cork inlay, or screw-on caps made of enamelled metal or plastic. The artificial red colour, amaranth, is not now permitted in these products, so tomato varieties (Pusa Ruby is one) must be employed which have a natural deep red colour that is also retained on cooking. Use of paprika will intensify the colour without affecting flavour. Tomato ketchup is 70 per cent water and 30 per cent solids, and packs 90 calories in 100g.

Worcester (pronounced Wooster) sauce has a thin consistency. The flavours are first extracted by separately macerating in vinegar various aromatic materials like tamarind, pepper, coriander, cloves, garlic, ginger, jaiphal (mace) and allspice (pimento or Jamaican pepper), filtering each extract, and then blending them, to give the flavour desired, with a ketchup made from the soyabean or walnut; to this may be further added soyabean sauce, sugar, and even sherry or brandy. The final blended sauce is usually mellowed for at least three months before bottling.

Preparation of soyabean sauce (or shoyo in Japanese), with its dark colour, salty taste and nutty flavour, is a complicated affair. Soaked soyabeans are mixed with roasted wheat, inoculated with a special *Aspergillus* mould and held under forced aeration for 3 days. The mass is mixed with a lot of salt solution and allowed to ferment over a period of 6 months, during which the temperature

is alternated from low to high and to low again in a very controlled sequence. The final soyabean sauce has a lot of salt (18 per cent) and sugars (upto 10 per cent), besides soluble proteins and their breakdown products, lactic and other organic acids, and many flavouring constituents. The sauce acts as a salting, flavouring and colouring agent, both at the table and in Chinese cooking.

Papads

Usually deep-fried but sometimes roasted, papads or pappadams generally connote flat circles of various sizes. Other products of the same genre may have lumpy, strand-like or wafer-type shapes. All are crisp, and contribute a crunchy component to the textural range of an Indian meal and a pleasant, slightly salty taste. Long made in the home from regional and family recipes, papads are now available commercially in raw form for finishing in the home, and thus qualify as processed foods.

An essential ingredient of the flat papad is dehusked urad or black gram dhal; this carries a mucilaginous component that gives cohesion to the papad dough (and plays a part also in the texture of an idli and a dosai). In a true papad, urad dhal can only be replaced to a certain extent, but never completely, by other dhals like mung, tuvar and chana. Papad flavours can be varied by incorporating in the dough various spicy elements like fragments of dried chilly or black pepper, chilly powder and ground garlic or onion.

Well-powdered and finely-sieved urad dhal is kneaded into a dough with water, salt and sodium bicarbonate (baking soda). The latter is called papad kar or sajji kar in the north and appalakaram in the south; sometimes country potash or potassium carbonate is also employed. The dough is rolled out very thin, cut into circles that vary from 10 to 25 cm in diameter, dried in the sun, and stacked in piles after dusting with fine rice flour to prevent sticking. Salt, apart from taste, softens the dough and contributes to its extensibility, besides playing a part in the expansion or blooming of the papads on frying. Salt also aids storage, though use of too much will attract moisture during the monsoon or crystallise on the surface, and too little may invite mould growth. The use of bicarbonates and carbonates mellows the rather raw

flavour of urad dhal and brightens the colour. Finished papads weigh between 5 and 20g. They carry the 22 per cent protein level of the pulse itself; if fried, there is also half their weight of absorbed fat, so the nutritive contribution of a single 10g papad can be as much as 50 calories.

CHAPTER 10

From Tins and Bottles

Jams, Jellies, Squashes, Preserves and Candied Fruits

THE USE OF just sugar for preserving vegetables as a murabba was examined in the previous Chapter, and much the same principles apply in making fruit-based sweet products. While sour and sour-sweet vegetables tend to be sold in bottles for convenience, sweet produots are vended both in bottles and in tins, or cans to employ American usage. The principles that operate in the making of these products, and later in packing them for sale, will be related to the actual recipes described in Table 10.1. These are for the preparation respectively of a squash, cordial, jelly, jam, fruit-in-syrup, preserve, candied peel and crystallised fruit.

Juices in fruits

The first recipe is for mango squash and no heating at all is involved. Preservation is achieved by the use of plenty of sugar and citric acid, besides the preservative KMS; as we saw in the last Chapter, this releases sulphur dioxide that keeps at bay the mould spores and bacteria which would give rise to vinegar. After filling in sterilised bottles to the top, it is essential to use new corks that have been boiled thoroughly in water to sterilise and soften them. Old corks are certain to harbour microorganisms which will spoil the squash in a short time. Industrially, screw-on caps of enamelled metal or plastic, sometimes even without an inner lining circle of cork, have replaced the crown corks with a wavy edge that were once used, but which are found today mainly on bottles of soft drinks, carbonated beverages and beer.

The lime cordial recipe is for a clear, very tart product, with

KMS added to reduce the risk of mould growth on the surface, an occurrence which is not uncommon.

Food colours

In the first two recipes, use of a suitable edible colour heightens the appeal of the products, but has no nutritional or preservative functions. At present, 11 synthetic colours are permitted in foods under the Prevention of Food Adulteration Act, which is the regulating legislation in India, but even this list may be reduced because of fears regarding safety. Thus amaranth, a red colour once widely used, has been banned after laboratory experiments using animals suggested that it diminishes fertility, induces birth defects and may even produce cancer. Another red dye, Ponceau 4R, is also facing a ban because of its tendency to lower the number of red blood cells. There is even a suggestion to ban the use of all synthetic colours in foods; on the other hand, research work is in progress to develop a range of colours from natural products like grape skins, safflower florets, beetroots and so on.

The importance of being pectin

The third recipe, for guava jelly, is no more than a method for the extraction of pectin. This is a natural substance of great importance in making jams and jellies, which is found in rather large amounts in the pith of citrus fruits; below the skins of the guava, apple, green papaya and mango; in the rind of the jackfruit; and in the pulp of the woodapple. All these materials can be extracted in the home as described in the third recipe, and used for making jams with materials that are naturally deficient in pectin. When extracting pectin, a simple test is used to determine its quality. To a spoonful of the extract, add two teaspoonfuls of methylated spirit or rectified spirit. Formation of one big clot indicates a high pectin content, several small clots a medium content, and a thin gelatinous precipitate a low content. If low, continue boiling the extract to concentrate the pectin. Commercial pectin is available as a powder; this is best employed by mixing with 5 times its weight of sugar, and thereafter dissolving in water.

Pectin is what causes a jelly or a jam to set, and three materials, namely pectin, sugar and acid, must be in proper balance to get a good product. At a given level of pectin, use of less sugar and

TABLE 10.1

Some fruit-based products

1. Mango squash

Mango pulp 1 kg
Water 1 kg
Sugar 1 kg
Citric acid 30 g
Potassium metabisulphite (KMS) 0.6g
Edible orange-yellow colour Optional

a. Separate the pulp without skin or stones from fresh, fully-ripe, tart and juicy mangoes

b. Mix the pulp with water, sugar and citric acid thoroughly without heating

c Strain through coarse muslin cloth

d. Add the KMS and colour (e.g. Sunset Yellow, Orange AG), each dissolved in a little water

e. Pour into clean bottles that have been sterilised by washing in hot water, leaving just 2 to 3 cms headspace. Seal air-tight with a crown cork, or tightly with a new wetted cork, or a used cork thoroughly boiled in water.

2. Lime juice cordial

Lime juice 1 kg
Sugar 1.25 kg
Water 1 kg
KMS 1.5+0.3g
Edible yellow-green colour Optional

a. Wash the fresh, fully-ripe lime (kagazi nimbu) fruits thoroughly and cut them in halves

b. Squeeze the juice from them by hand or using a squeezer. Strain the juice through coarse muslin to remove seeds and pulp

c. Add 1.5g KMS, and store for 4 to 6 weeks in glass bottles

d. Decant the juice carefully from the sediment, add the sugar, water, colour and KMS (0.3g). Bottle as in Recipe 1.

3. Guava jelly

Guavas 1 kg
Citric acid 2g
Sugar See recipe

a. Use ripe but rather tart fruits with a thick pulp. Wash, cut into thin slices

b. Just cover the pieces with water, add the citric acid, and boil for 30 mins, stirring occasionally with a ladle, till the mass shows stickiness

c. Strain through coarse cloth, and make one more similar extract. Mix the extracts and settle overnight. Decant the clear portion

d. Test this for pectin using alcohol (see text). If low, boil the extract down gently to concentrate the pectin

e. When high enough, add three-quarters of its weight of sugar and boil till the jelly drops from the spoon not as a steady syrup, but as flakes or sheets

f. Pour hot into sterilised jars, and screw-cap.

4. **Pineapple jam**

Pineapple pulp 1 kg
Sugar 1 kg

a. Remove the pineapple crown, the peel and the eyes to leave only the fruit

b. Cut into small pieces, crush them thoroughly to get a uniform mass

c. Add the sugar, stand for one hr, and cook slowly with vigorous stirring till the consistency of a jam is reached (remember it will thicken further on cooling)

d. Fill the hot jam almost to the top into a sterilised bottle standing on a wooden board or thick cloth pad to dissipate heat. Screw down the lid, invert the bottle for 5 mins to also sterilise the lid, and cool.

5. **Canned sapota**

Sapota segments 550g
Sugar 1250g
Water 1000cc
Citric acid 55g

a. Place the deskinned sapota segments in a A-2½ size can

b. Make a solution of the sugar and citric acid in water, to yield a 55° Brix syrup

c. Boil the syrup and pour it into the can to fill the fruit interspaces leaving about one cm at the top

d. Place the can in boiling water for 7 to 8 mins. Seal the can

e. Cook the sealed can in boiling water for 25 mins. Cool thereafter.

6. **Pear preserve**

Pears 500g
Brine solution To cover
Edible yellow or red colour Optional
Sugar As required
Citric acid As required

a. Wash fruits, cut off both ends, peel. Cut into quarters and core. Cover with 2 per cent brine solution to prevent browning. When required cook in boiling water for 5 mins to soften them and remove salt

b. Colour the pieces if desired by boiling with dye solution. Wash. Prick the pieces with a stainless steel fork

Contd.

c. Boil for 5 mins in a sufficient quantity of a solution of 43g sugar in 100cc water (30° Brix) containing 0.2 per cent citric acid, and stand overnight

d. Next day draw syrup, add more citric acid and enough sugar to raise the strength to 67 per cent (40°Brix). Repeat boiling and cooling with sugar syrup of increasing strength to a final one of 2 to 3 threads (70°Brix, 233g/100ml)

g. Pour while fairly hot into dry sterilised bottles and cap. This preserve will keep for a year.

7. Candied ash gourd (petha)

Cubed ash gourd 500g
Quick lime 60g
Sugar As required

a. Dice the firm flesh, discarding skin and seeds. Prick with a fork

b. To firm the fruit, immerse in fresh lime water solution (60g quicklime to one lit. water, allow to settle, and use clear decanted solution) for 3 to 4 hr (a soft fruit will require longer). Drain, wash well with water

c. Soften the pieces by placing in boiling water for 15 to 30 mins. Remove, drain moisture on a cloth

d. Prepare a syrup of one kg sugar in 1.5 lit. water. Boil syrup, remove scum and add the pieces. Continue heating to a 2 to 3-thread consistency

e. Leave overnight. Drain syrup, dry on a wire tray or cloth till no longer sticky. Store in a dry shallow covered container.

8. Crystallised pomelo (chakotra) peel

Pomelo peel 500g
Salt As required
Glucose Optional
KMS As required
Sugar As required
Citric acid 0.1 g

a. Remove all pulp from the peel, and cut into rectangles 2 cm by 10 cm

b. Immerse the pieces in 8 per cent common salt solution, to which some glucose may be added to hasten the process. Leave for 6 weeks when the pieces should be translucent

c. Then place in 10 per cent salt solution carrying 0.2 per cent of KMS, in which they can be kept for 3 months

d. When needed, soak repeatedly in warm water and wash with water to remove salt. Prick from inside with a fork to facilitate syrup absorption

e. Cover with a solution of 43g sugar in 100cc water (30°Brix) and leave for 2 days. Pour off the syrup, raise the sugar strength to 67g in 100cc (40°Brix), boil for 5 mins and let stand for 2 days. Continue in this way upto 75°Brix (300g/100cc) to which the citric acid has been added, and after standing for 2 days, boil for 5 mins, and drain the hot syrup

f. Roll the sticky pieces in finely-ground sugar, and dry on trays. Store in dry glass bottles.

more acid, or of more sugar and less acid, will give a good product. So a big saving in sugar can be made by adding a little more citric or tartaric acid. Fruits high in both pectin and acid are sour apples, guavas, oranges, plums and lemons. Fruits rich in pectin, but low in acid, are unripe bananas, pears, ripe guavas and various citrus peels. Most ripe and overripe sweet fruits like apricots, peaches and strawberries are low in both pectin and acid.

Boiling a jelly or jam is an important step apart from the cooking action. It brings the three components into intimate union, while gradually increasing the sugar concentration. The finishing point is judged by lifting the hot product in a spoon, and allowing it to fall back into the pan: it should do so as a flake or sheet, and not in a stream.

A marmalade is simply a jelly with suspended solid material. The jelly can be sweet or sour, and the solids are often mildly bitter shreds of orange or lime peel that have been preboiled to soften them. A little orange oil will enhance the flavour lost during boiling, and a pinch of KMS acts as a preservative.

Inverting sugar

While a jelly or a marmalade are fruit extracts, jams carry the fruit pulp itself. In the example given, the pineapple pulp is almost completely disintegrated by crushing, and the same is true of mango, guava, apricot and banana jams. But jams from fruits

like the strawberry, raspberry, cherry, mulberry and grape gain character if the fruit is in recognisable form, though of course soft and spreadable.

We have noted that boiling cooks the fruit, bonds the materials present, and thickens the syrup. It has also another important effect. When sugar is boiled in the presence of citric acid and concentrated, the sucrose breaks down into two smaller pieces, glucose and fructose, a process called inversion (p. 72). The mixture is even sweeter than sugar, and yet it will not crystallise as sugar could do if its concentration in the jam is too high. In many jams, some 50 to 80 per cent of the sugar is present in inverted form.

Bottling is done hot into sterilised bottles; the lids are screwed on tight, and the hot bottle is inverted so as to also sterilise the lid. In commercial practice, the bottles (or sealed cans, if these have been used), are again pasteurised at 90°C for 30 mins to ensure the death of all organisms. Jams can also be canned by the same process described in Chapter 9 for the canning of peas in brine (p. 135).

Jaggery is best not used in place of sugar to make jam, since both the bright colour and the taste are adversely affected.

Sugar has strength too

The canned sapota (cheeku) recipe is really very simple. the very high content of both sugar and citric acid reinforcing each other to act as a preservative. The sugar used is a 55° Brix solution, which means that 55 parts of sugar are added to 45 part of water. This works out to 1.22 kg of sugar in a litre of liquid, which represents a fairly strong solution. In the next recipe, for pear preserve, a weaker 30°Brix solution (30 parts sugar to 70 parts water) is first used. This is later raised in strength to 55°Brix strength, which will give one thread when pulled apart between the thumb and forefinger, and finally to a 2 to 3-thread consistency corresponding roughly to 70°Brix. This slow build-up of sugar prevents the fruit from shrivelling, as would happen if the pear pieces were put in very strong sugar syrup all at once. Boiling at each step along with citric acid is designed to achieve inversion of part of the sugar. As we have seen, invert sugar does not itself crystallise, and also prevents sugar from crystallising and spoiling the looks and mouth-feel of the preserve.

It will be noticed that in the pear recipe the freshly-cut pieces are covered with salt solution till used. This is to prevent their turning brown, something we have all commonly experienced with apples. The brown colour results from the oxidation of certain substances called polyphenols present in these fruits by an enzyme, also present, when exposed to the oxygen of the air. This enzymatic browning is much faster than the Maillard reactions which give rise to brown products during the processing of many foods, including fruits and vegetables.

Sweet all the way

The last two recipes involve heavy sugar preservation. Ash gourd pieces are dipped in slaked lime to make them firm, and then boiled down in sugar syrup to a high Brix value of 70 to 75°. The sugar in inverted form enters the fruit thoroughly and will therefore not crystallise but remain syrupy. Candied ash gourd with its sweet, crunchy mouth-feel is a popular sweetmeat.

The last recipe utilises the thick rind of the citrus fruit pomelo, called chakotra in India and grapefruit in America. Initial brining, just as in pickling lime, causes salt to enter the peel and make it translucent; later this salt is washed away. Immersion of the pieces in sugar solutions of increasing Brix strength (to which citric acid is added to achieve inversion) leads to thorough permeation of the peel. The final rolling in sugar crystals gives a sugary "crystallised" appearance to the product. If the peel is covered with a thin transparent coating of sugar, giving it a glassy appearance, the product is called candied peel. Final drying of all these sugar products is important, and commercially this is done by circulating warm air around the product held on wire trays; improperly-dried sugared products or those packed in wet containers can attract mould, and use of KMS helps to avoid this.

Another means of averting the crystallisation of sugar is to employ an equal mixture of glucose (or corn syrup) and sugar to saturate the fruit tissues. This also enables the boiling step to be avoided, which is an advantage with certain kinds of already-soft fruits like the mango and peach.

Preserving by drying

Lowering the moisture content below a certain level will also leave

microorganisms without a foothold. Such dried fruits have a venerable history of use wherever fresh produce is not to be had, such as out of season, in desert areas, in theatres of war and so on.

Raisins, kishmish in Hindi, are made in Baluchistan from seedless grapes which have the necessary natural high sugar content of 20 to 24°Brix. Ripe bunches are hung inside a dark room till they dry out to acquire a light green to amber tint. In California, the pink, musk-flavoured Muscat grape is dried to yield raisins, and the greenish-brown Thompson seedless variety to yield sultanas. Fully-ripe fruit is dipped momentarily in dilute caustic soda solution on which floats a thin layer of olive oil. The caustic soda removes the wax on the grape surface, and the fruit gets coated with a fine layer of oil which prevents cracking on subsequent drying and gives each raisin a gloss. The grapes are spread on trays and exposed to the sun for 4 to 6 days, then softly turned over and again exposed for a similar period. The last stage of drying is done in the shade and lasts a week. If seedless grapes are exposed prior to drying to burning sulphur for disinfestation, the sultanas have a translucent, off-white appearance.

Dried apricots (shakarpara) are imported from Afghanistan, and represent the sulphur-treated, dried product from a small white apricot. Dried dates are mainly a product of the Middle-East, made by sun-drying such date varieties as Deglet-Noor, Khadrawi and Halawi either to a hard dry state (called chhuhara in India) or to a still moist, succulent level (the common khajur) at which stage the sugar has mostly become inverted to glucose and fructose. A certain amount of dates is grown in India in Gujarat, Rajasthan and Haryana Punjab, dried in the sun after spreading out on mats and packed as bundles in the latter.

Dried figs, strung on strands of some strong vegetable fibre, are mostly derived from large, white Smyrna figs grown in countries surrounding the Mediterranean, and in the USA. In India the so-called Poona figs, after initial sulphuring, are sun-dried for a week and pressed flat while still not fully dry. They are finished by dipping in boiling salt water to soften them and improve their taste.

Apple rings are threaded fresh, and then dried by hanging the necklaces in the sun.

Two products native to India are dried jackfruit and dried mango

juice. Jack bulbs are destoned, cut into strips and the latter sun-dried with or without sulphuring; they can be soaked in water for reconstitution, or used as such for deep frying to chips. Green mango strips are similarly sun-dried and used after powdering as a souring agent. Ripe mangoes of the *rasah* varieties, *cheruku* (small) and *pedda* (big), which grow in Andhra Pradesh and are extremely juicy, are used to make a product called *am ras* (mango extract) or *am papad*. The pulp is squeezed out, spread on bamboo mats, sprinkled with sugar and sun dried; thereafter another layer of pulp is laid over the first and so on to a thickness of 3 to 5 cm. The light brown product has a delicious sweet-sour flavour, and and a layery texture. Similar drying of the pulp of the guava, banana and papaya, and the use of modern drying systems and preservatives, can yield delicious fruit bars with potential for use as chewy confections, as fruit chunks in ice-cream or butter spreads, and as substitutes for raisins and candied peel in baking.

Fruit juices and powders

A fruit juice is essentially the liquid pressed out from the fruit, to which a little sugar may sometimes be added to balance any tartness, whereas a squash may in addition have some citric acid. From fruits like the orange, pineapple, grape and apple, the juice is extracted from the pulp using a press, and strained free of seed and coarse solids. Usually some sugar is added, after which the juice is heated, bottled and sterilised. Most fruit juices except cordials are cloudy because they carry finely-suspended solid materials, and such cloudiness has come to be expected and relished by the consumer.

Several fruit juices are now concentrated using vacuum to retain their flavour, and distributed to dispensing units all over the country, in which they are reconstituted using chilled water and sold as refreshing beverages.

Fruit juices can be roller-dried or spray-dried into powders which can be made up in the home. The CFTRI Mysore has developed a new technique of drying the juice after adding an edible foaming agent in small quantities; the fluffy powder so obtained reconstitutes very easily with water and the taste is well retained.

Do processed foods retain vitamins ?

Fruits carry two vitamins in particular. Vitamin C is the "sour" vitamin which is easily destroyed by air, heat and light; in fact it is the most sensitive of all the dozen or so vitamins known. Vitamin A is present in fruits in the form of its precursor, carotene, which is yellow in colour; in the body carotene is converted into vitamin A. Table 10.2 shows the levels of these two vitamins in some common fruits and a few fruit products. Fruits rich in vitamin C are the amla, cashew fruit, country guava, raw papaya and all citrus fruits, while vitamin A-rich fruits are all mango varieties (Badami and Raspuri particularly), fresh apricot, raspberry, ripe papaya, phalsa berry and ripe tomato.

TABLE 10.2

Vitamin contents of some fruits and fruit products

Values for every 100g edible portion

	Vit. C milligrams	*Vit. A micrograms*		*Vit. C milligrams*	*Vit. A micrograms*
Amla (nellikai)	600	5	Melon, musk	26	85
Apple	1	Nil	Melon, water	1	Nil
Apricots, fresh	6	1080	Mulberry	12	29
Banana, ripe	7	39	Orange :		
Ber	76	11	Mosambi (sathkudi)	52	Nil
Cape gooseberry (kodinellikai)	49	714	Coorg	26	Nil
Cashew fruit	180	12	Nagpur	21	Nil
Cherries, red	7	Nil	Papaya, ripe	57	333
Dates, soft-dried	3	13	Passion fruit juice	30	35
Figs	5	81	Peach	6	Nil
Grapes, blue or white	Nil	Nil	Pear	Nil	14
Grapefruit juice	31	Nil	Phalsa	22	210
Guava, country	212	Nil	Pineapple	39	9
Guava, cultivated	15	Nil	Plum	5	83
Guava jelly	43	Nil	Pomegranate	16	Nil
Jackfruit	7	83	Pomelo	20	60
Lime	63	8	Raisins	Nil	Nil
Lime juice	40	1	Raspberry	30	624
Mango :			Sapota	6	49
Badami	20	2800	Sitaphal	37	Nil
Banganapalli	16	—	Strawberry	52	9
Langra	176	—	Tomato, ripe	27	176
Totapuri	8	916	Tomato juice	16	24
Others	13 to 18	ca.1000	Tomato ketchup	18	44
			Woodapple	3	32
			Adult daily requirement	40	750

How much of these vitamins can be expected when a bottle or tin of the product is bought ? Dried fruits and pulps would carry little if any vitamin C, and perhaps half the vitamin A in the fresh fruit. Fruits in syrup, jellies and jams may be expected to contain three-quarters of the original vitamins C and A, and fruit juices about the same quantity of vitamin C when purchased. In addition, most tinned foods will have picked up small amounts, of the order of 20 to 50 ppm, of tin and iron on storage; these are totally innocuous.

Buying canned foods

Because canned foods are cooked, sterilised to destroy all spoilage organisms, and packed in vacuum, they can keep for long periods: fruit at least for a year, vegetables for 2 years, meat and fish for 5 years, fish in tomato sauce for a year and condensed milk for a year. These periods can even be exceeded. Once opened, most foods will last as long in the can as ordinary cooked food, and longer in a refrigerator. It is best to empty fruit from the can into a glass dish, as the flavour does change if held for a while in an open tin. Any juice in a can may be consumed too: one need not throw it away. If stored in damp places, cans of food may rust and get perforated, when the contents quickly become unsafe.

Cans that are swollen at the ends, which stubbornly spring out again if pushed in, are a sign that fermentation is taking place inside from undestroyed microorganisms to release carbon dioxide or alcohol. Such cans must be rejected, since the contents are sure to be inedible, and may even harbour the deadly poisonous organism, *Clostridium botulinum*. Swelling of the tin can occur from causes other than fermentation: hydrogen formation as a result of corrosion of the can, overfilling of its contents, or insufficient exhausting. Though none of these render the contents unfit for consumption, it is best to play safe and discard such tins. A sourish or flat taste in canned vegetables may not be revealed in a bulging can, since it has occurred in the vegetable before the canning operation. But anything that smells or tastes even slightly abnormal should not be eaten. The lacquer coating inside a can is frequently of a golden colour; a grey hue shows that the iron has not been properly coated with lacquer, and has reacted with the hydrogen sulphide generated by the protein component of the ood to give iron sulphide. Reject food in such cans.

CHAPTER 11

Satisfying That Sweet Tooth

Chocolate, Cocoa and Confectionery

CHOCOLATE

Cocoa history and geography

IT WAS THE inhabitants of ancient Mexico who discovered the use of the cocoa bean for making chocolate, calling it the food of the gods. The Latin name, *Theobroma cacao*, codifies this connection. At first the Europeans called the bean cacao, but later this became corrupted to the more easily-pronounced cocoa. There is no resemblance whatever between cocoa and the familiar coconut, even when the latter is wrongly spelt cocoanut !

The conquering Spaniards carried the cocoa bean to Europe and its fame soon spread. The cocoa tree requires a warm, moist climate and somewhat special soil conditions in which to grow. It seems to do best in a somewhat narrow geographical belt 20° on each side of the equator. At present Ghana and Nigeria are by far the largest producers of cocoa beans, with Brazil and the Cameroons making minor contributions.

South India lies in the right geographical belt and has so diverse a climatic range that it is not surprising that the cocoa tree is faring well in Karnataka, Tamilnadu and Kerala. The tree grows to a height of 8-10 metres, and lives for 50-60 years. It starts yielding after four years and is most productive from about the age of ten to thirty. The Forestero variety, which is robust and high-yielding, constitutes over 90 per cent of the crop worldwide. The Criollo variety, though better flavoured, is less important. Being rather expensive, the demand for raw or finished cocoa products in India is not likely ever to be high, but they are certain of a very

large and lucrative export demand in affluent countries. Moreover cocoa tree-planting need not erode existing land usage for basic food crops.

How chocolate is made

The cocoa fruit or pod is crimson in colour, and of the size of a medium cucumber, about 8 cm across and 15-25 cm long. Each fruit contains 25-40 seeds or beans embedded in pulp, again as in a cucumber, though the seeds are much larger. The fruit is allowed to rot by fermenting, after which the cocoa beans are collected, dried and put into bags for shipment all over the world.

Raw cocoa beans are bitter and astringent to the taste, and the peculiar cocoa or chocolate aroma only develops when the beans are roasted There is an analogy to what happens when the coffee bean is roasted to develop its own special coffee aroma. After roasting, the outer shells of cocoa beans become brittle and are easily broken away and discarded, leaving behind the valuable kernels. These are called cocoa nibs, perhaps because the jagged edges resemble sharp fountain pen nibs.

Cocoa nibs carry over 50 per cent oil, 10-15 per cent proteins and 20 per cent digestible carbohydrates. There is very little crude fibre, and the nibs can therefore be ground to a very fine mass. The heat developed during such grinding also causes the fat to melt and the ground mass if cooled in moulds sets to a dark brown, slightly bitter block which is used in cooking as plain, dark, unsweetened chocolate.

To make sweet chocolate, milk chocolate and so on, the ground mass must be mixed with other ingredients like sugar, milk and flavourings. Also, it is important to achieve a very fine, velvety texture when the finished chocolate is put in the mouth. To obtain smoothness, the ground mass is passed between heavy metal rolls cooled with water, and thereafter ground for 2-3 days in what is called a conche. This consists of a smooth trough inside which moves a smooth stone or porcelain roller, which not only grinds the cocoa paste but slaps it about. The slight heat developed during this slow conching serves to bring out the full flavour of the chocolate.

The slurry that comes out of the conche must next be tempered. Tempering is a process of just melting the chocolate, cooling it with continuous mixing to produce tiny crystals of the solid fat

that is present, and then quickly mixing these to achieve a uniform distribution in the mass. Considerable thickening takes place at this stage, and the hot mass is poured into plastic trays, which are then chilled to the temperature of melting ice so that the chocolate will set into a convenient bar or slab. During setting, there is a slight contraction, and when the tray is inverted and given a sharp tap, the chocolate slab drops out. The fat also imparts a beautiful shine to the surface of the slab. It has however another property which is not so nice. If the fat has not been fully tempered, what happens is that on long storage of the chocolate, the fat slowly oozes to the surface of the bar. Here it forms a white, powdery layer, called chocolate bloom, which certainly spoils the appearance of the slab. Proper tempering will reduce such bloom formation on subsequent storage of the chocolate bar, and also improve both keeping quality and surface gloss.

Cocoa powder and drinking chocolate

The ground cocoa mass, as we have seen, has a lot of fat in it. If it is passed between filter pads at high pressure and temperature, this fat is squeezed out, and sets on cooling to a pale cream or brown solid. Cocoa fat, or cocoa butter as it is called, is a hard, brittle, shiny fat with a pleasant chocolate odour which is in great demand for making confectionery all the world over. Because of these unique characteristics, it is one of the most costly fats that exist, the gold among all fats. Cocoa butter melts sharply when put in the mouth, leaving no unpleasant oily sensation. It shrinks slightly on cooling, and as we have seen this is what enables the chocolate bar to be cleanly tapped out from the mould. Scientists in many countries continue to spend much effort to find substitutes, or even extenders, for natural cocoa butter.

About half the fat present can be squeezed out, and the pressed material which remains, still containing about 25 per cent fat, when ground and sieved constitutes cocoa powder. This is slightly bitter, and is used to give a pleasant flavour and brown colour to puddings, custards and ice-creams. Blended with flavourings and sugar, the powder gives drinking chocolate, which when stirred into milk yields an appetising beverage.

Chocolate as a food

A chocolate bar is a food of high nutritive value, carrying as it

does the three major nutrients : carbohydrates, proteins and fats. Addition of milk further enhances the nutrient content. Cocoa powder, the raw material for chocolate manufacture, furnishes 500 calories for every 100 grams, plain chocolate about 545, milk chocolate 590 calories. Thus it is a concentrated high-energy foodstuff, and certainly of value for children provided they are not already obese. Of course, like all sweet foods, chocolate when it lodges in the dental crevices is liable to enhance caries or the pitting of teeth (see Chapter 4). Thorough mouth washing after eating sweets will prevent this.

Even plain chocolate is a good source of quite a number of minerals. Here are the levels of these, in terms of mg in a 100g of chocolate: potassium 250, sodium 145, phosphorus 140, magnesium 130, calcium 63 and iron 3 (these last two are about one-eighth of the daily needs of a child). In milk chocolate these levels are even further raised, except for magnesium and iron which are lowered since milk is poor in these two minerals.

Drinking chocolate is of course used in teaspoon amounts to enhance the appeal of a glass of milk, and so its nutritive value is not of great consequence. A heaped teaspoon of drinking chocolate will raise the energy content of a glass of buffalo milk, which is 500 calories, by another 40 calories.

Cocoa products, like tea and coffee (Chapter 6) owe their refreshing qualities in part to two mild stimulants that are present, caffeine and theobromine. Both stimulate blood circulation and excretion of urine, caffeine being by far the more powerful. Neither is cumulative or habit-forming, but in heart patients they are best avoided, while in highly nervous or dyspeptic persons they may cause loss of sleep, palpitation and depression. Coffee and tea contain mainly caffeine (40 to 60 mg per cup) with a little theobromine (2 to 3 mg), whereas cocoa carries mostly the milder theobromine (250 mg per cup) accompanied by a little caffeine (6 mg).

Mothers nursing their children are advised to go easy on cocoa-containing products. Theobromine passes rather rapidly into breast milk, is not easily metabolised by infants, and can cause allergic symptoms in them. Cocoa contains histamine and tyramine in bound form, and could give rise to allergies in susceptible individuals.

SWEETS

Sweets

If sugar syrup is boiled down till it thickens, and then allowed to cool, the sugar will crystallise out in the form of grains because it is only slightly soluble in the water present. To prevent this, sugar should be combined either with about two-thirds its weight of invert sugar which we learnt about in the making of jams (Chapter 10). As we saw, this consists of glucose and fructose, both of which are highly soluble in water. If mixed with sucrose solution, they will prevent the crystallisation or graining of the sugar when sweets are made. Moreover, invert sugar is even slightly sweeter than sucrose, so this property also does not suffer.

Liquid glucose is another material used to prevent sucrose from crystallising. Liquid glucose, or glucose syrup as it is sometimes called, is made by breaking down the linked glucose units present in some appropriate kind of starch, for example corn starch, using hydrochloric acid (Chapter 4). Liquid glucose is slightly less sweet than sugar itself, but this hardly affects the taste of the boiled sweet: in fact it may even be considered to soften and improve it.

Boiled sweets are made by thickening down a mixture of sugar and either invert sugar or liquid glucose till almost all the water has gone. Skill is required to decide when to stop. The thick syrup is then cooled in moulds coated with oil or flour to prevent sticking. When the sweets have cooled and hardened, each is wrapped attractively in cellophane.

Many variations of flavour are possible. Lemon, orange and other fruit flavours are very popular, while stronger flavours like mint and peppermint are used too. The addition of citric, tartaric and lactic acids confers a pleasant acidic tartness.

TOFFEE

Butterscotch and toffee are very similar to "glassy" boiled sweets, except that sweetened condensed milk, butter or caramel are incorporated into the sugars during cooking, and more water is finally left in. To impart chewiness, gelatine is employed. Pastilles are made by including gum arabic or other edible gums, often along with strong flavours like lemon, liquorice, eucalyptus and menthol.

Nutritional value

Since sweets are mostly sugar, they will essentially provide energy. This is available quickly since sugar is absorbed and metabolised rapidly. A rise in blood sugar can be noted experimentally soon after sweets are eaten. This can kill the appetite for more food, which is why children should be discouraged from eating sweets just before their main meals. The connection between sweets and dental caries has been pointed out earlier in this Chapter, and in some detail in Chapter 4.

CHEWING GUM

Spaniards travelling to Mexico four centuries ago noticed the unusually white teeth of Aztec girls who were in the habit of chewing chicle, the sap of the giant sapodilla tree. General Santa Anna, who conquered the legendary Davy Crockett at the battle of the Alamo in 1836, introduced the practice into the USA. In 1869, Bill Wrigley took out a patent for chicle coated with sugar and flavoured with spearmint oil, which has a lemony tang. It is said that he was really searching for a new material with which to make false teeth, but suddenly saw its possibilities as a new form of confectionery !

For long chicle was employed as the base for chewing gum, and was tapped by hardy climbers called chicleros from the tops of the 60-foot high sapodilla tree trunks. Today synthetic resins are used as the base, and they can be varied to give chewy and bubbly gums. These are totally insoluble in water and saliva, and can therefore be chewed almost indefinitely. The coating is essentially a combination of sugar with some precipitated calcium carbonate and titanium dioxide to give it a dazzling whiteness. Flavours can be varied, but some menthol is essential for a "cool" effect.

The sugar coating is soon swallowed, and dentists have claimed that chewing gum strengthens the teeth and jaws, stimulates saliva, and works off and thus reduces tension. It is perhaps a harmless addiction, except that the residual sticky mess is almost indestructible, and presents a massive collection and disposal problem where gum chewing is widely prevalent.

CHAPTER 12

Down The Hatch

Soft drinks and Alcoholic drinks

SOFT DRINKS

Bottled fizz

SPRING OR SPA waters that are naturally rich in minerals and often sparkling to look at are even now favoured for drinking in Europe. Nearly two centuries ago the impregnation of water with carbon dioxide to give an effervescent liquid was discovered. Such "soda" water, with its characteristic metallic taste, is still popular for consumption by itself or as an accompaniment to whisky or gin. Variations in flavour by the addition of fruit juices followed soon after, and in 1809 came the first commercial preparation of synthetic soft drinks of the kinds now available.

What are the essential characteristics of these aerated waters, and how are they achieved ? It is not enough to have a fizz by forcing 3 or 4 volumes of carbon dioxide into water at high pressure: the bubbles must remain for a fair period of time after the bottle is opened. For this certain types of chemicals, called ethylene oxide polymers, are used in very small amounts of say 100 parts per million. To impart sweetness, sugar is just not sweet enough: a lot of it would be required and the cost would be high. Hence synthetic sweeteners which are much sweeter than sugar (see Chapter 4) are used, though these have to be specifically permitted by law. In India only saccharin is allowed; it is about 300 times as sweet as sugar and upto 100 parts per million are allowed, which is sufficient along with the 5 per cent sugar used alongside. Each sweet drink bottle with a volume of 180 cc

will therefore carry 9g of sugar and 18 mgms of saccharin. In other countries, other sweeteners are permitted such as cyclamates (30 times as sweet as sugar) and glycyrrhizin (derived from the liqorice root, and used as its ammonia derivative which is 50 times as sweet as sugar). It is believed that the thirst-quenching properties of carbonated drinks are due in part to the slight pressure on the abdomen caused by the gas in the stomach. The presence of acidic materials has been found to help in satiating thirst, as for example in fresh nimbu pani. Citric acid is the most popular of these, especially for such fruit-flavoured beverages as lemon, lime, orange, pineapple and apple. Grape-like drinks often use tartaric acid which is actually found in grapes, and heavier-flavoured products, like the cola drinks, use phosphoric acid which makes them very acidic indeed. Another factor which appeals to a thirsty person is a cloudy or frosty appearance in the drink. This is achieved in an interesting way. Citrus oils, with their flavours of lemon, lime and orange (these may be either natural or synthetic) are blended with brominated vegetable oils to give a mixture of suitable specific gravity very close to that of water. This mixture is thoroughly blended with water using an edible grade of emulsifier (such as gum arabic) which also serves to stabilise the emulsion. In the bottle itself, fine droplets of this flavoured material remain suspended in the drink, giving it both a uniform flavour and the desired cloudy appearance. Synthetic flavours are complicated mixtures; a pineapple flavour could be made up of 10 pure chemicals and 7 natural oils ! Colours to match the flavour are used: an orange colour for an orange-flavoured beverage, green for a lime beverage, pink for strawberry, and caramel or burnt-sugar for many cola beverages with a tawny hue. Preservatives like benzoates and sulphur dioxide are permitted by law in carbonated drinks, but are not used, since the carbon dioxide itself, coupled with the acidity, is itself a powerful preservative.

To make a typical aerated soft drink, carbon dioxide is forced under pressure into pure chilled water containing materials to retain the fizz after opening. Separately a solution of the sweetener, acidic material, and colour is put together. This is blended with an emulsion of citrus oils and brominated vegetable oils, the clouding agent. This mixture, and the bulk of the water, are fed in separate streams into a bottling machine. The filled bottles then go to a

capping machine which puts on each a metal crown cap, lined on the inside with a washer made of cork, which will hold the pressure till the bottle is opened.

Used bottles are collected, and thoroughly washed and cleaned before being filled again. Each bottle is re-used 35 to 40 times in this way, for 3 or 4 years.

Are fizzy drinks healthy ?

Except for the sugar that it contains, an aerated drink furnishes no calories at all. It is in fact nutritionally an empty food, giving at most about 70 calories in each bottle consumed.

Some of the ingredients call for comment on other grounds. The high degree of acidity, especially where phosphoric acid is used as in the cola-type drinks, is hardly to be recommended when gastric acidity is of common occurrence, as it is in India. The synthetic sweeteners used are increasingly under attack. Cyclamates are not permitted in India; in animals they have shown evidence of impairing reproductive function, and are suspected of provoking cancer. Saccharin too, if not a carcinogen itself, is in the dock as a suspected co-carcinogen that potentiates other materials. It has shown this effect when used in the aromatic masalas put into betel leaf paan, which is held for long periods against the cheek. However the use of saccharin over the last half century by millions of diabetics, some even for decades, suggests that it may well be safe. Brominated vegetable oils used as clouding agents have also been banned (in the UK, for example) after it was shown that bromine accumulated in the body fats of humans.

The cola nut is the seed, about 3 centimetres in size, of a large tree growing in Brazil, the West Indies and West Africa. It was traditionally chewed as a stimulant by the Sudanese, much in the manner of betel leaves, arecanuts or tobacco elsewhere. The nut contains about 2.3 per cent of caffeine, which is extracted with water or alcohol and the extract flavoured for use in soft drinks. Extra caffeine may also be added to such extracts. A bottle of cola drink will contain about 40 mg of caffeine, very similar to the quantity in a cup of tea or a cup of chocolate (cocoa). As we have seen when considering tea and coffee (Chapter 6) and cocoa (Chapter 11), little harm comes from consumption of these quantities of the mildly-stimulant caffeine. Where children are concerned

however, consumption of fizzy drinks of no food value, which simply fill them up and kill their appetite, is not desirable.

ALCOHOLIC DRINKS

The celebrated Dr Spooner was supposed to have remarked on the "affluence of incohol", yet alcoholic beverages seem to be used at all levels of affluence in many countries and climes. A mild degree of exhilaration through alcohol, when some inhibitions are suppressed, could perhaps contribute to a feeling of general well-being. Most very long-lived communities are found to be regular if moderate consumers of alcohol.

Alcohol is burnt in the body and so provides calories proportional to the quantity present in the drink. Beer and toddy each carry about 40 calories in every 100 cc, which comes to about 100 calories per glass. Wine carries 100 calories and since it is drunk in larger volumes than are most other drinks, in Europe for example, it could contribute quite substantially to calorie intakes. Whisky, gin and brandy furnish about 250 calories in a 100 cc; this is about the quantity that constitutes a peg, which is poured into a glass and made up with water or soda.

Only beer and toddy contain any nutrients other than calories. Two vitamins of the B-group, riboflavin and niacin, are present, but no thiamine or ascorbic acid. A 250cc glass of beer provides about one-tenth of the needs of an adult, but a glass of toddy only a quarter that of beer.

Fermented Indian liquors

Toddy: The toddy palm is a familiar sight, crowned with its characteristic fan-shaped leaves pointing upwards. Its sap is intensely sweet, carrying about 12 per cent of sugar. The sap is obtained from the spathes, the three bracts which envelop the cluster of flowers, through sharp, deep incisions made on them in the early morning or late evening. An earthen pot is tied below the gash, and about a litre or two of sweet toddy or neera will collect over the next two days. Repeated tapping can be done on each tree for 9 months in the year. Fermentation of the sugar present, through enzymes which exist alongside, starts immediately the juice collects, but can be delayed by coating the inside of the pot with lime. Palm toddy has a characteristic and very strong smell, and

the alcohol level can vary from 4 to 10 per cent. To get a stronger "kick", chloral hydrate is often added to toddy, though this is both illegal and harmful.

Arrack is distilled toddy, with a sourish taste and aroma, and a powerful intoxicating effect since it is 70-80 per cent alcohol. Other types of arrack are also known, based on fermented rice, fermented molasses, or mixtures of these with palm toddy.

Feni is the distilled product from the fermented juice of the yellow-red cashew fruit which carries 11 per cent of glucose. The tree was introduced into India from Brazil about four centuries ago by the Portuguese traders who followed Vasco da Gama. Incidentally these enthusiasts also brought the groundnut into this country. Feni has a characteristic phenolic flavour and taste, and carries 40 per cent alcohol or more.

Rum was developed in Jamaica and elsewhere in the West Indies by fermentation of sugarcane juice or molasses, followed by distillation and maturing for at least two years in wooden casks. In India teak wood and sal wood are used for the latter purpose. The strong flavour is caused by the presence of esters like ethyl acetate and of various aldehydes, while the sharp taste derives from tannins extracted from the wood. The use of caramel or burnt sugar to build up the brown colour is permitted in India. To reduce the long period of aging, which is expensive since capital is locked up, accelerated methods are being used both for rum and whisky preparation. These include exposure to infrared or ultraviolet radiation, or oxidation with oxygen or ozone.

Liquors originating in the West

A variety of alcoholic drinks, developed historically in the Western world, have now found a place in developing countries. Originally made in the home, in family establishments or in monasteries, today these drinks are manufactured in volume by adapting traditional technologies to modern production methods.

Grain-based products

Beer has a history of at least 6000 years in all the cradles of civilisation—Babylon, Mesapotamia, Egypt, China—and was once simply fermented barley. The addition of bitter cones from the hop vine started in the ninth century for medicinal purposes. Beer

preparation is a complex process, every step and detail of which has a part to play in the appeal of the final product. Barley is first steeped in cold water for 2-3 days and then spread out to germinate (sprout or malt) for 10 days or so, and the malted mass is next dried in a kiln with a current of warm air. It is then extracted with warm water (even the composition of this water is important), after which the extract is boiled and hops gradually added over two hours. After cooling and settling, the wort is drawn off through the layer of hops, and then fermented with the addition of enzymes by way of brewers' yeast for periods of 7-14 days. The particles settle and the clear beer is held in a cold cellar for 3 to 6 weeks for further final clarification by settling, after which it is carbonated, and then filtered or centrifuged so as to achieve a sparkle in the bottle. The bitter taste which forms part of the appeal of beer is due to resins and resin acids derived from the hops. Off-flavours arise through undesirable types of fermentation yielding hydrogen sulphide, acetic acid, lactic acid and so on. The foam that characterises beer when it is poured out has been traced to surface-active sugar-proteins produced during malting. These same surfactants are also believed to protect the bubbles of carbon dioxide as they rise slowly through the mug. Possibly albumins and hop resins also play a role in the generation and retaining of the foam.

Lager or *Pilsener* is beer of low, 4-6 per cent alcoholic content ("light") produced by bottom rather than surface fermentation, and matured by storage after fermentation (lager means stored in German).

Ale, popular in the UK, has a higher alcoholic content through some degree of surface fermentation, and a bitter taste through use of a greater quantity of hops.

Stout is even more bitter and very dark in colour.

Whisky is likewise made from grain, usually barley, but no hops are used. The grain is first malted and dried in a kiln, the wood or peat employed in these kilns imparting its own flavour to the whisky malt and thence to the whisky. The kilned malt is then extracted with water, and the resulting wort is fermented either as such or after filtration. The alcohol thus formed, along with other substances that have been generated alongside, is concentrated by distillation two or three times. This distillate is next

aged slowly in corked wooden casks for four to six years (the statutory requirement is three years, but periods of upto 12 years are practised). Such maturation develops small quantities of numerous products (esters, acids, alcohols, aldehydes and tannins) which taken together give fine whiskies their smoothness and appeal. Alongside even 20 to 25 per cent of the liquid may be lost by evaporation. One traditional method is to carry out the ageing in oak barrels that have formerly held sherry. Sometimes charred wood chips are added to impart a smoky flavour. *Scotch whisky* is made from filtered wort. In India a product labelled malt whisky has to be derived only from cereals. Blended whisky must contain at least 10 per cent of malt whisky: the rest can come from beets, molasses or other sugar-containing materials.

Rye, popular in Canada, is whisky derived from the cereal rye, and made from an unfiltered wort.

Bourbon is made from barley, maize (corn) or wheat. All these distilled products carry 40-50 per cent alcohol.

Vodka is a distilled product made from barley, rye, maize or potatoes. The congenerics produced during fermentation are excluded by rectification during distillation, so that vodka is in effect a dilute alcohol of 40 to 60 per cent alcohol content.

Gin is a bland distilled alcohol to which natural essential oils of various flavours are added in small quantities. The many *liqueurs* are blends of rectified alcohol with sugar, aromatic flavours and colours, which may sometimes be added even prior to alcohol distillation. Liqueurs have a perfume-like character, whereas *cordials*, made similarly, carry a more spicy note.

Fruit-based products

Wine is a general term for a product containing about 10-15 per cent alcohol made by the fermentation of a number of sugar-containing materials, fruits in particular. Grapes are by far the most important of these, but other fruits (banana, orange, apple) can be used as well. So can starch-rich materials like rice, which in Japan is fermented to give the product *sake*. The type of grape most commonly used is *Vitis vinifera* of which there are said to be 5000 varieties. They carry the wine yeast *Saccharomyces ellipsoideus* on the skin so that no additional enzyme need be added. Grapes contain little or no sugar (sucrose), but about 10 per cent each of

dextrose, a form of glucose, and fructose, and about a half per cent each of tartaric and malic acids. A low tannin level must accompany the two sugars, and in the best wines, cane sugar will never be added before fermenting. In India, Thompson Seedless, Beauty and Black Muscat yield good wines, but Anab-e-Shahi and Bangalore Blue are less suitable. Dark grapes can be made to yield both red and white wines, but white grapes yield only the latter. Table wines, whether red or white, must be "dry", which connotes a high acid and low residual sugar content. Dessert wines are "sweet", and this is sometimes achieved by the addition of grape sugar (never cane sugar). Ordinary wines season quickly and then go stale after a year, whereas the grand wines season very slowly and continue to improve even after scores of years. Wine spoilage is caused by the growth of acetic acid bacteria which cause a sour or vinegary taste, or of lactic acid bacteria which give rise to sediment and a mousy taste. The variety of the grape, the soil on which it is grown, the climate in any particular year, the temperature, time and method of fermentation, and so many other factors come into play that it is not surprising that distinctive wines have developed in almost every country and even region of Europe. Great vintages are rated by expert wine tasters.

Burgundy, for example, uses grapes grown on a calcium-rich soil: Chardonnay grapes without the skin for white wine, and Pinot Noir with the skin on for red. These are harvested in the coolest period of the day, fermented very slowly at a low temperature of 30°C and then aged for two years in small casks in cool cellars. *Champagne*, the name of a district in France, is made again from a blend of the same two grapes so as to give a balance of alcohol content and fruitiness. The whole fruit is pressed directly without deskinning, fermentation is carried out in the cold, and the wine is filtered. It is then given a second fermentation in bottles at 13°C for several years to develop its sparkle (caused by build-up of carbon dioxide under pressure), high alcohol content of 10.5-11 per cent, tartness and finesse.

Sherry derives its name from the town of Jerez in Spain and gets its characteristic sweet, fruity bouquet and dark colour from the high alcohol content, low residual sugar level and a "baking" operation at a really high temperature of 49°C for 4 to 6 months. In fact some Spanish sherries are left to age for 2 years under a

heavy mat of surface yeast. *Port*, named again after the town of Oporto in Portugal, draws its red colour from the grape skins which are frequently turned or trodden with bare feet during fermentation; when the wine is run off, the skins are pressed again to draw off colour. Ageing of sherry and port is done slowly for 4 to 8 years in oak casks. *Muscatel* is from grapes of the same name which have both a high sugar content and a pronounced flavour. These are also the grapes favoured for making raisins. *Vermouth*, which can be sweet or dry, is wine fortified with herbs or spices, and *cider* is an English product made by fermenting cider apples, thereafter sweetened with sugar and sometimes finally carbonated.

Brandy is a distilled wine, and the wine can itself be made from many fruits: the grape, apple, cherry or cashew. Frequently a wine that is below par in its alcohol strength and taste will yield a superb brandy on distillation and subsequent maturation, a process which may run into years or even decades.

Cognac is a term reserved for distilled white wine made from grapes grown around the French town of that name with a phosphate-rich soil.

Modern wine-making

Red wines are factory-made by fermenting crushed whole blue grapes (to which some sulphur dioxide, potassium metabisulphite or potassium bisulphite is added to suppress mould growth) with 2 to 3 per cent of a mixed fermenting culture or better still a pure *Saccharomyces* yeast starter. After 3 or 4 days the mass is pumped into tanks where fermentation continues for six weeks. The top liquid is now drawn off from the sediment, filled into tanks which are tightly closed, and allowed to ripen for 2 to 3 years with a filtration operation at the end of every year. A final filtration through paper is given to "polish" the wine before bottling, and the bottles are kept for 6 months before release to the market. White wine is fermented at a cooler temperature in tanks or casks filled to the brim, and with limited access to air at least till the first filtration. Even thereafter the operation is kept closed as far as possible to prevent undesirable acidity development through growth of acetic acid bacteria.

Making wine and liqueur at home

Much pleasure can be had by making alcoholic drinks at home and some recipes are given in Table 12.1 on pages 167 and 168.

TABLE 12.1

Wine and liqueur recipes

1. Grape wine

Sound grapes 1+10 kg
Saccharomyces ellipsoideus pure culture
Sugar 2+1 kg
Potassium metabisulphite 1 teaspoon
Citric acid 1 tablespoon
Glass conical flask with a narrow neck
Pressure cooker
Plastic bucket, 20-litre
Glass or polyethylene carbuoy with a narrow neck
Air-lock (glass) half filled with water (drawing)
Cotton wool for plugs

a. Prepare a starter a week ahead. Crush 1 kg of grapes to get 500cc of juice. Add 1 tablespoon of sugar. Place in a glass conical flask, plug with cotton wool, and sterilise in a pressure cooker for 10 mins. Cool. Add the yeast powder, plug, and put aside to ferment.

b. Wash 10 kg of detached grapes in a plastic bucket with warm water. Extract the juice in a juicing machine or by hand.

c. Place the juice in the carbuoy. Add to it (a) a cooled solution of 2 kg sugar in 3 litres boiling water (b) a teaspoon of potassium metabisulphite and (c) a tablespoon of citric acid. Mix thoroughly and plug.

d. After 6 hrs. add the starter prepared a week earlier. Mix thoroughly, and put aside preferably at 25-30°C for 10 days of active fermentation.

e. Decant (rack) the wine into a plastic bucket to separate it from the seeds and skins. Then transfer the wine back into the carbuoy. Add 1 kg sugar as a cooled solution, mix, and put on the air-lock. Leave 15 days for secondary fermentation.

f. Again rack the wine from the settled solids. Repeat such racking at suitable intervals both to get a clear wine and to prevent undesirable flavours being picked up from dead yeast cells.

g. After 3 to 4 months, when fermentation has ceased, fill the wine into sterilised bottles, plug with corks, sterliise in boiling water, and seal with paraffin wax. Makes 6 bottles.

2. Orange wine

Loose-jacket oranges 12
Raisins 250g
Sugar 750g
Yeast 1 tablespoon
Brandy 6 tablespoons

a. Peel oranges, remove pith from segments, and mash up. Place in a jar along with raisins and sugar, and pour in 8 cups of boiling water. Cool. Add yeast, mix, keep in a warm place for 3 days for active fermentation.

b. Take the peel from one orange, roast in an oven till light brown. Pour on it half a cup of boiling water and cool. Add to the jar. Mix. Cover jar with a muslin cloth, move to a cool place and leave undisturbed for 3 weeks for secondary fermentation.

c. Siphon into bottles (about 6). Add one tablespoon of brandy to each bottle. Plug with sterilised corks, leave for 2 months to mature.

3. Spicy ginger

Green ginger ½ kg
Cloves 1 tablespoon
Whole cardamoms 24
Bright red chillies with stalks 12
Sugar 1 kg
Tartaric acid ½ teaspoon
Brandy or rum 4 tablespoons

a. Scrape ginger, cut into thin circles.

b. Place ginger pieces, cloves, cardamom, chillies and sugar in a large, clean vessel, add one litre of water and bring to a boil. Lower heat and simmer for one hour till colour develops. Cool.

c. Add tartaric acid. Strain through flannel overnight. Place in bottles (3). Top each bottle with a tablespoon of brandy or rum. Improves with age.

4. Coffee rum liqueur

Coffee brew 150ml
Sugar 250g
Salt Pinch
Rum, 100° proof, 400 ml
Coffee essence 30ml
Coffee rum flavour 2 teaspoons

a. Prepare 150ml of a very strong coffee brew. Add the sugar.

b. Add the coffee essence, a pinch of salt and 400ml of rum to give a 55° proof liqueur.

c. Add coffee rum flavour and mix.

However, a few points must be stressed. For the first recipe, sound ripe grapes must be used, whether white or blue. Scrupulous cleanliness is essential at every stage to prevent microbial contamination, and also vinegar flies. A good fermentation culture of *Saccharomyces ellipsoideus* yeast should be obtained from a laboratory, brewery or food shop. On no account should baker's yeast from a breadmaker be used. During the secondary fermentation of the bulk of the juice, the container should be fully filled and an air-lock (see p. 167) fitted on top using a bored new cork to permit gas to escape while keeping out unwanted microorganisms. After the main fermentation is over, and the wine is matured in bottles, it will deposit yeast for several months. If the wine is left too long on this yeast, a mousy flavour can develop, so racking should be done frequently. In the first two recipes, to get a good bouquet, the season chosen for the long period of secondary fermentation, and the room used, should be as cool as possible, but the initial active fermentation is best done in a warm room in the house.

The last two recipes, for a spicy ginger wine and a coffee liqueur, derive their alcohol from brandy or rum, and their flavouring is artificial.

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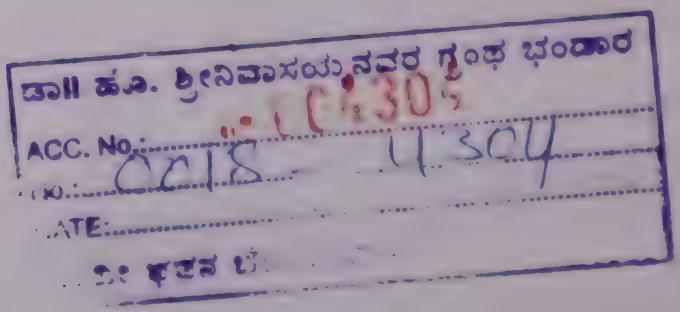

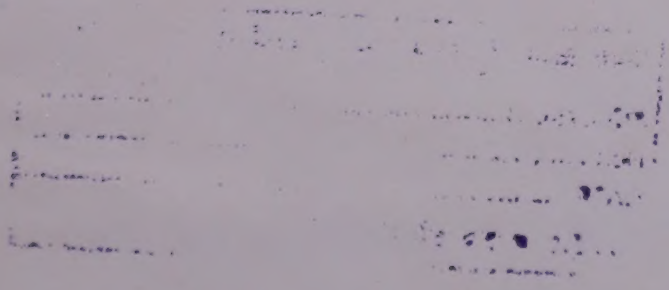

The present volume outlines the chemistry, technology and nutritional quality of the entire range of both primary foods like rice, wheat, milk and vegetable oil, and of more sophisticated processed foods like bread, biscuits, jams, pickles, vanaspati, chocolates, papads, idlis and milk sweets to name but a few. Even a casual dip will serve to show the lively and interesting way in which a tremendous amount of information has been presented for the lay reader.

Dr. K.T. Achaya is the author of an earlier book, Your Food and You, *also published by the National Book Trust, India, which ran into several printings in English. It was translated into a number of Indian languages, and won a national award for excellence in its category.*

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